

### Key message

**Polybrominated diphenyl ether (PBDEs) concentrations in biota (fish and shellfish) and sediment in the four Scottish biogeographic regions generally remain below the threshold at which adverse effects occur in marine life, but above natural background concentrations. Mean concentrations are stable or decreasing in the assessment area over the assessment period (1999 - 2018).**

### Background

Polybrominated diphenyl ethers (PBDE) were one of the most widely used groups of brominated flame retardants (BFRs). BFRs reduce fire hazards by interfering with the combustion of polymeric materials. PBDEs were first used in the 1970s and between 1970 and 2000 it has been estimated that approximately 12,000 - 15,000 tonnes of penta-BDEs were produced in Europe. PBDEs are persistent, bioaccumulative and toxic and due to concerns about their environmental impact they were banned in Europe in 2004. Since the ban their main sources are from the disposal of PBDE treated products.

PBDEs often associate with marine sediments, where they remain in lower layers unless the sediments are disturbed. PBDEs can also accumulate in shellfish and fish, where they are taken in either directly from the marine environment or indirectly through food consumption.

Analysis of PBDE in sediment and biota (fish and shellfish) is required for the OSPAR Coordinated Environmental Monitoring Programme (CEMP) and the Marine Strategy Framework Directive (MSFD). To fulfill these monitoring commitments, heavy metals are monitored in sediment and biota is undertaken in Scotland as part of



Figure 1:  
A day grab is used to collect sediment from the seabed for contaminant analysis. In this case the day grab was operated from the MRV Scotia.

the UK Clean Seas Environmental Monitoring Programme (CSEMP) for 4 biogeographic regions (Figure 2): Irish Sea (Clyde and Solway), Minches and Western Scotland, Scottish Continental Shelf and Northern North Sea. See [Introduction to SMA2020](#) for more about the areas used.

## Results

PBDE concentrations are measured in sediment and biota (shellfish and fish) samples taken between 1999 and 2018 from four biogeographic regions (Figure 2), in cycles varying from annually to every six years. Only biogeographic regions with at least three stations with a reasonable geographic spread were included in the regional assessment of status and trends. Shellfish (blue mussel) were collected in coastal and estuarine areas only whilst sediment and fish were collected from coastal and more offshore areas.

PBDE concentrations in sediment and biota (blue mussels and fish liver) were compared to the OSPAR Background Assessment Concentration (BAC). BACs are used to assess whether concentrations are close to zero for man-made occurring substances, such as PBDEs. In addition, PBDE concentrations in biota and sediment were compared to the Federal Environmental Quality Guidelines (FEQG). Adverse effects on marine organisms are rarely observed when concentrations are below the FEQG.

There were sufficient sites for a status assessment of sediment and biota (fish and shellfish) in the Irish Sea (Clyde and Solway) and Northern North Sea, as well as for sediment in the Minches and Western Scotland region. Trends could only be assessed in the Irish Sea (Clyde and Solway) and Northern North Sea for both sediment and biota. The highest PBDE concentrations in sediment and biota were in the Irish Sea (Clyde and Solway), which includes the Clyde, the most industrialised and urbanised Scottish sea area. PBDE concentrations in sediment, particularly in the offshore areas of the Northern North Sea, are low with most PBDE congeners being below the analytical detection limit. Across all PBDE congeners, the status assessment for sediment and biota was the same for all regions, with mean regional concentrations being above

the BAC but below the FEQG (Figure 3). Therefore adverse biological effects in marine species are unlikely. However, 8 of 28 sediment sites and 7 out of 25 biota sites report concentrations of at least one PBDE congeners that are not acceptable (> FEQG).

Trends in PBDE concentrations were assessed in biogeographic regions where there were at least five years of data (Figure 4). Two regions were assessed for trends in sediment and biota. Across all PBDEs concentrations were stable in biota and sediment from the Northern North Sea. In the Irish Sea (Clyde and Solway) mean % yearly changes were negative (improving) in both matrices, with significant decreases in biota.

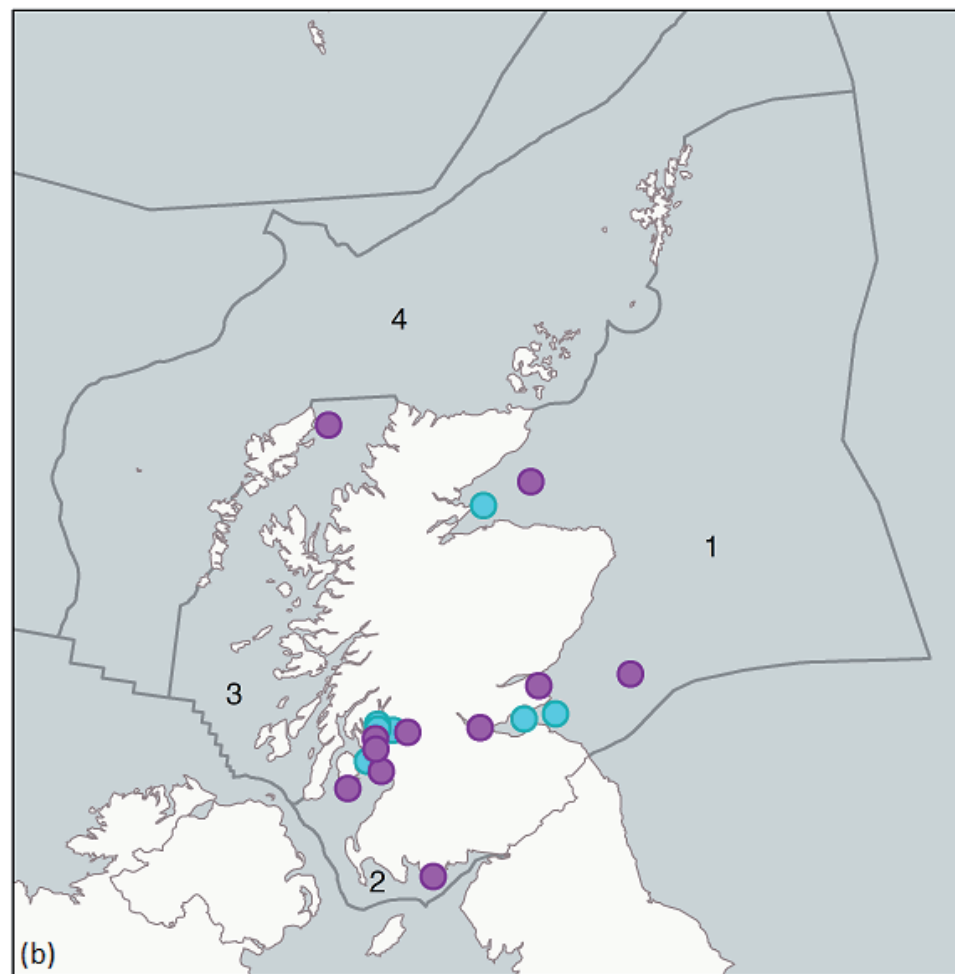
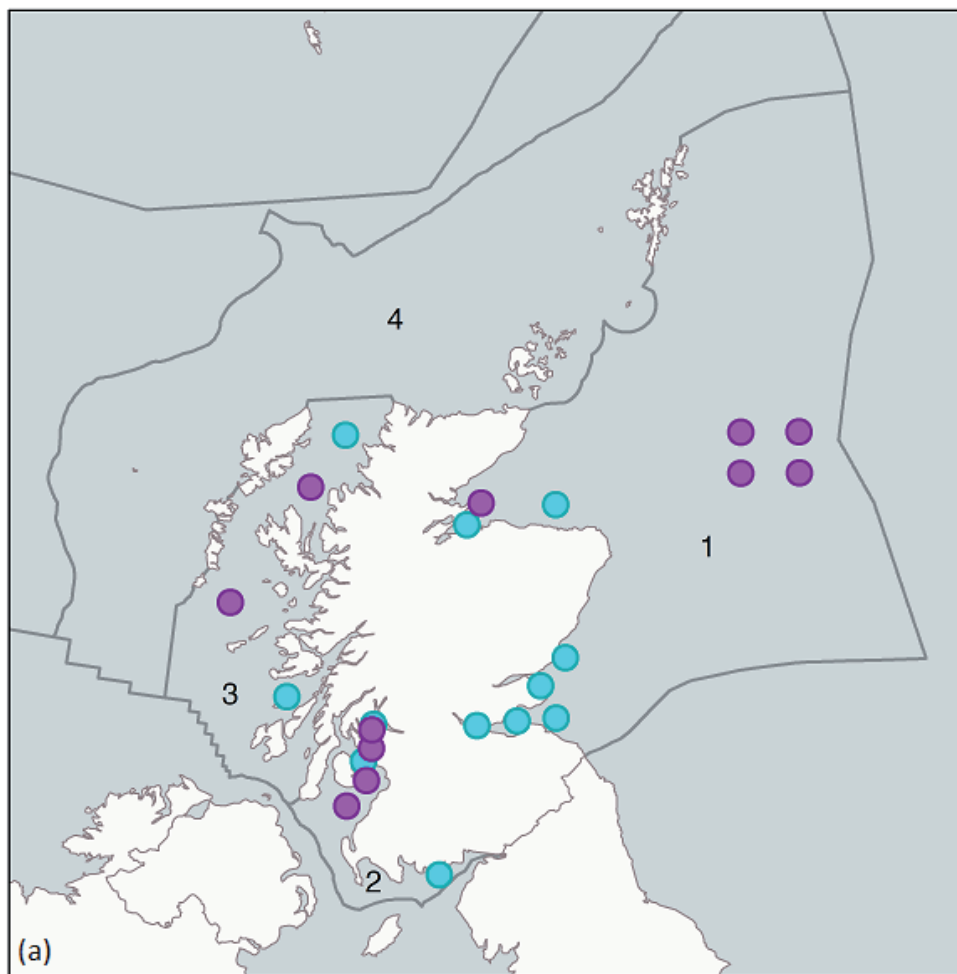


Figure 2: Monitoring stations used to assess PBDE concentrations in (a) sediment and (b) biota (shellfish and fish) per biogeographic region (grey lines). Magenta dots = stations used for trend and status assessments. Cyan dots = stations used for status assessment only. 1, Northern North Sea; 2, Irish Sea (Clyde and Solway); 3, Minches and Western Scotland; 4, Scottish Continental Shelf.

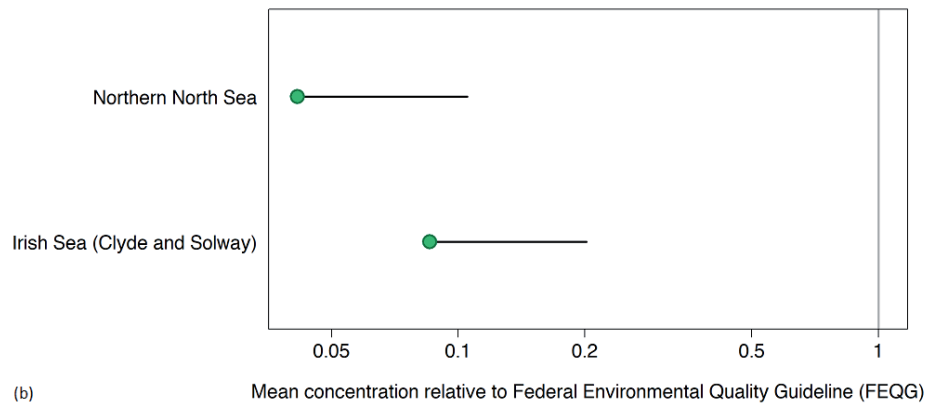
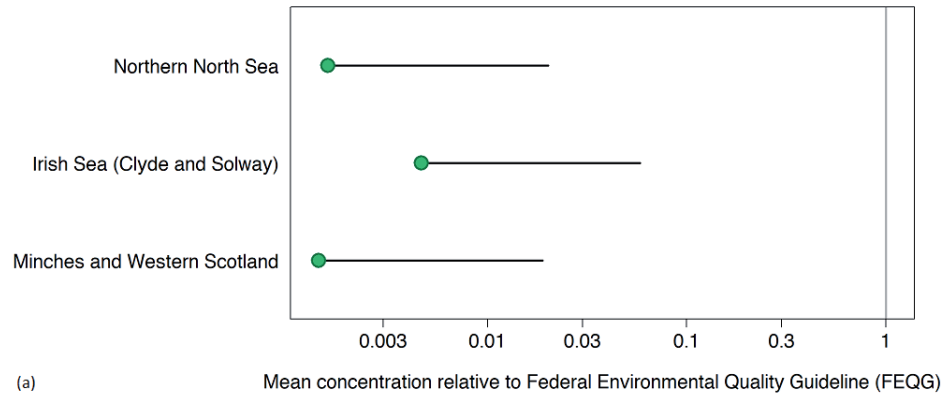


Figure 3: Status assessment; mean PBDE concentration in (a) sediment and (b) biota (shellfish and fish) in each Scottish biogeographic region relative to the FEQG (with 95% confidence limits), where the FEQG value is 1. Concentrations are significantly below the FEQG if the upper confidence limit is below 1. Blue = statistically significantly below the BAC. Green = at or above the BAC but statistically significantly below the FEQG.

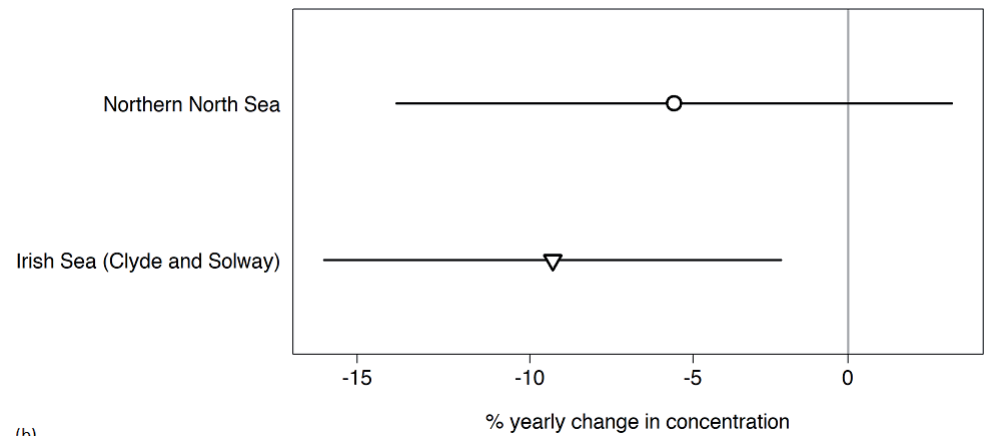
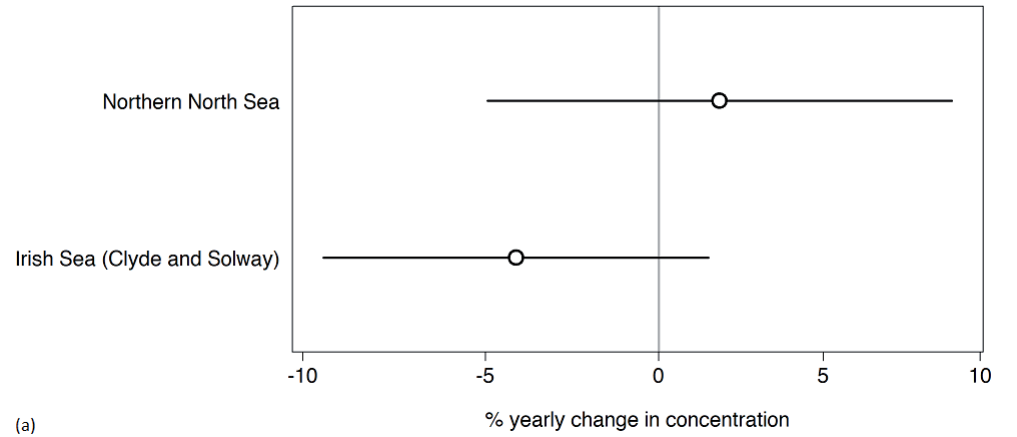


Figure 4: Trend assessment; percentage yearly change in PBDE concentrations in each Scottish biogeographic region for (a) sediment and (b) biota. There is a significant trend if the confidence limits does not cut the vertical line at 0. Upward trends (upwards triangle), downward trends (downwards triangle), no change (circle) and 95% confidence limits (lines).

## Conclusion

PBDE concentrations are low, particularly for sediment in offshore areas, frequently being below detection limits. However, mean regional concentrations in sediment and biota (mussels and fish liver) were above background concentrations in the assessed Scottish biogeographic regions. Mean PBDE concentrations were below the FEQG in all regions and therefore are unlikely to cause adverse effects in marine organisms. Assessment of trends showed that PBDE concentrations in sediment and biota are stable or decreasing in all areas.









## Knowledge gaps

There are a lack of monitoring data, particularly for sediment in the Scottish Continental Shelf. This is partly due to difficulties sampling in this area and the sediment type which is mainly sandy or rock and therefore not suitable for contaminant monitoring.



















The FEQG was used in the assessment as there are no OSPAR Environmental Assessment Criteria (EACs) currently available. There is a need for further development of EACs in sediment and biota.

## Status and Trend assessment

This status and trend assessment is an overall assessment for [Contaminants in sediment and biota](#) (PAHs, PCBs, PBDEs and metals in sediment and biota) and [Biological effects of contaminants](#).

| Region assessed                     | Status with confidence  | Trend with confidence   | Comments   |
|-------------------------------------|---|---|--|
| <b>Irish Sea (Clyde and Solway)</b> |    |    | Green square with red triangle for status indicates few or no concerns as a whole, but many local concerns, particularly in the Clyde, with some sites exceeding the EAC/EAC-proxy. Two stars for confidence in the status is due to lack of suitable assessment criteria for some determinands (metals in biota and some biological effects measurements) |
| <b>Minches and Western Scotland</b> |   |   | Two stars for confidence in the status is due to lack of suitable assessment criteria for some determinands (metals in biota and some biological effects measurements). In addition there is limited fish sites which impacts on the ability to make biological effects assessments.   |
| <b>Northern North Sea</b>           |  |  | Two stars for confidence in the status is due to lack of suitable assessment criteria for some determinands (metals in biota and some biological effects measurements)   |
| <b>Scottish Continental Shelf</b>   |  |  | One star for confidence in the status is due to lack of suitable assessment criteria for some determinands (metals in biota and some biological effects measurements). In addition this region could not be assessed for all determinand/matrix combinations due to the lack of sites  |

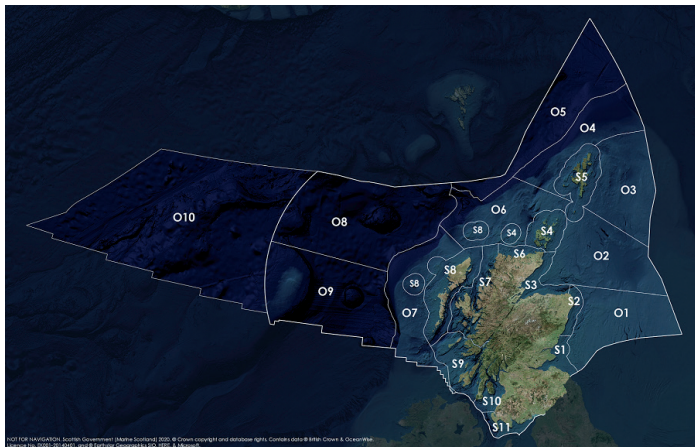
## Status and trend assessment legend

| Status assessment<br>(for Clean and safe, Healthy and biologically diverse assessments) |   | Trend assessment<br>(for Clean and safe, Healthy and biologically diverse and Productive assessments) |                      |
|---|---|---|----------------------|
|        | Many concerns   |                    | No / little change   |
|        | Some concerns   |                    | Increasing           |
|        | Few or no concerns  |                    | Decreasing           |
|        | Few or no concerns, but some local concerns   |                    | No trend discernible |
|        | Few or no concerns, but many local concerns   |                    | All trends           |
|        | Some concerns, but many local concerns  | <b>Confidence assessment</b>  |                      |
|        | Lack of evidence / robust assessment criteria   |   |                      |
|       | Lack of regional evidence / robust assessment criteria, but no or few concerns for some local areas |                   | Low                  |
|      | Lack of regional evidence / robust assessment criteria, but some concerns for some local areas      |                  | Medium               |
|      | Lack of regional evidence / robust assessment criteria, but many concerns for some local areas      |                  | High                 |

## Overall confidence

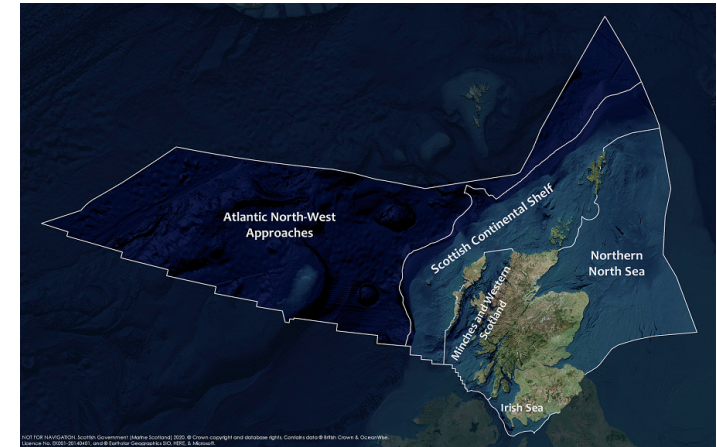


## Assessment regions

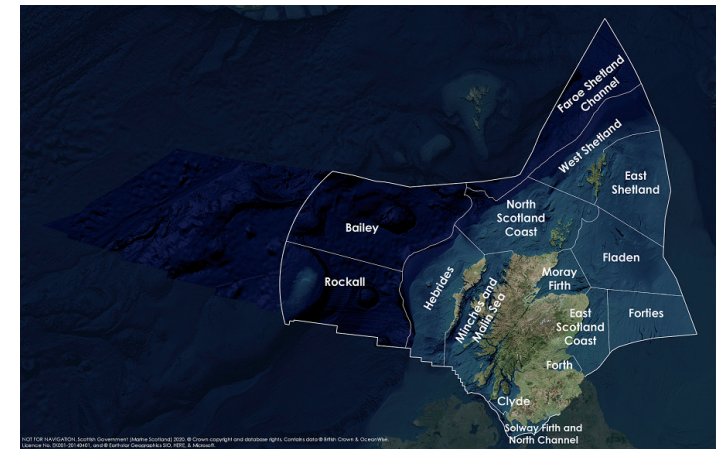


The Scottish Marine Regions (SMRs; S1 - S11) and the Scottish Offshore Marine Regions (OMRs, O1 - O10)

Key: S1, Forth and Tay; S2, North East; S3, Moray Firth; S4 Orkney Islands; S5, Shetland Isles; S6, North Coast; S7, West Highlands; S8, Outer Hebrides; S9, Argyll; S10, Clyde; S11, Solway; O1, Long Forties, O2, Fladen and Moray Firth Offshore; O3, East Shetland Shelf; O4, North and West Shetland Shelf; O5, Faroe-Shetland Channel; O6, North Scotland Shelf; O7, Hebrides Shelf; O8, Bailey; O9, Rockall; O10, Hatton.



Biogeographic, Charting Progress 2 (CP2) Regions. These have been used as the assessment areas for hazardous substances.



Scottish Sea Areas as used in Scotland's Marine Atlas 2011. These are sub divisions of the biogeographic, or Charting Progress 2 (CP2), Regions.