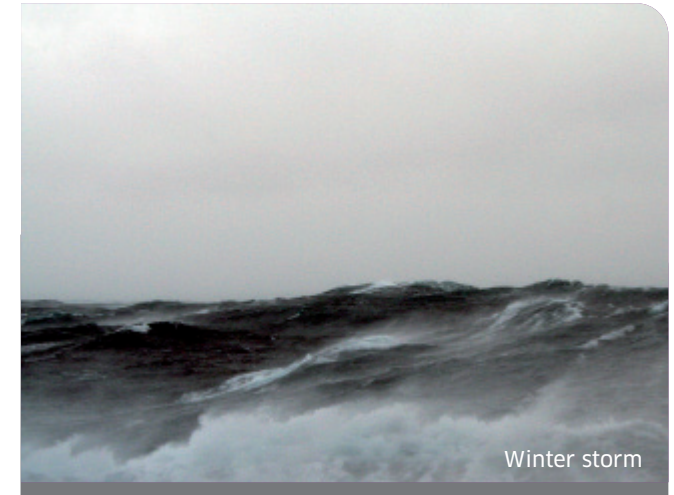


Winter nutrient concentrations



Key message

There was no statistically significant increase in the winter nutrient concentrations during the period 2007 to 2019 in any of the Scottish Marine Regions (SMRs) and concentrations are at levels that cause no concern.



Background

Eutrophication in the marine environment is the excessive growth of phytoplankton in response to enrichment by nutrients resulting in an undesirable disturbance in the marine ecosystem. The consequences are often wide ranging, with overall impacts on the diversity and abundance of flora and fauna resulting from the depletion of oxygen in the water column, increases in water turbidity and behavioural changes in larger fauna. However, nutrients such as dissolved inorganic nitrogen (DIN), dissolved inorganic phosphorus (DIP) and dissolved silicate (DSi) also occur naturally and are essential for primary production supporting the marine food web.

The main source of silicate in the marine environment is from the weathering of rocks, therefore local geology will influence silicate concentrations. Anthropogenic sources of nitrogen and phosphorous, including agricultural run-off and domestic and industrial waste discharges can result in elevated nutrient concentrations, particularly in coastal waters. Nutrient concentrations in Scottish waters exhibit a seasonal cycle, typical of northern latitudes. Phytoplankton (microscopic marine algae) biomass increases in the spring due to the increase in light and water column stability, and nutrient concentrations decrease as they are utilised by phytoplankton for

growth. Low light intensity and increased turbulence during winter limit phytoplankton growth and nutrients accumulate in the water column. In offshore waters nutrient concentration can also vary systematically with depth, with higher concentrations often found in deeper water below the light zone.

Marine Scotland Science (MSS) collect water samples to determine winter nutrient concentrations on an annual basis. Data produced are used in eutrophication assessments for OSPAR and the EU Marine Strategy Framework and Water Framework Directives.

This assessment evaluates winter nutrient concentrations and trends in the Scottish Marine Regions (SMRs) from 2007 to 2019.

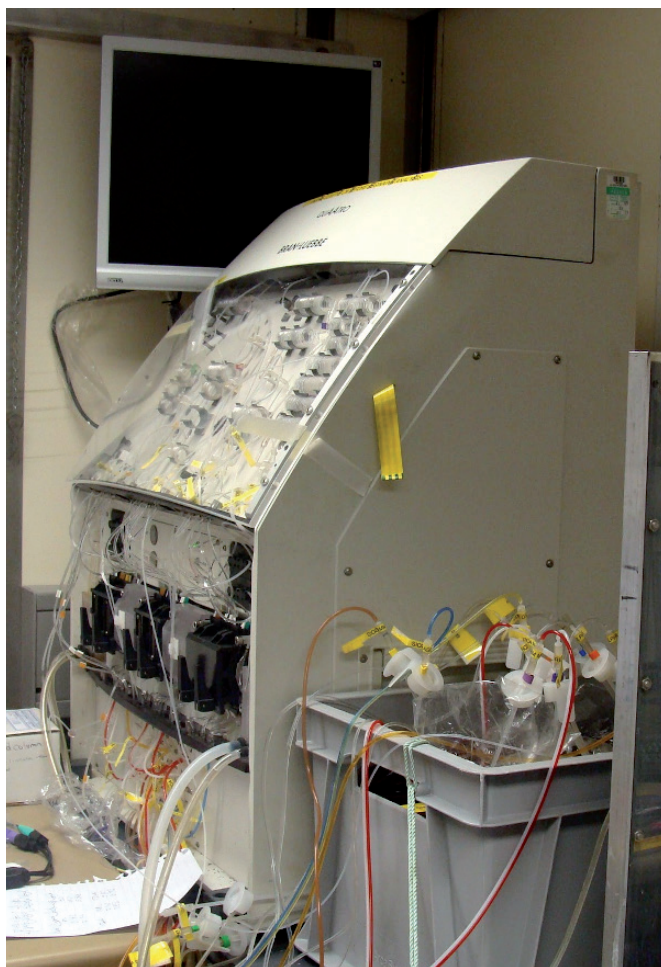


Figure 1: Winter Nutrient Analysis in the containerised laboratory on *MRV Scotia*

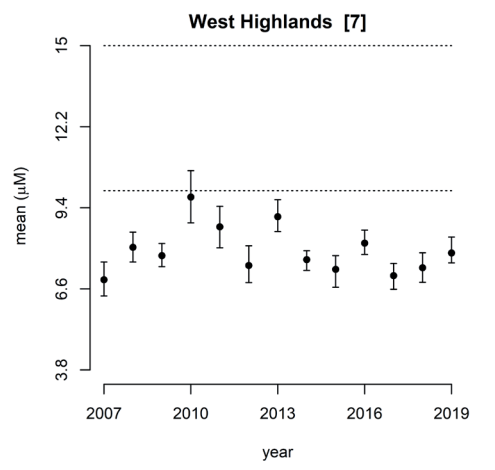
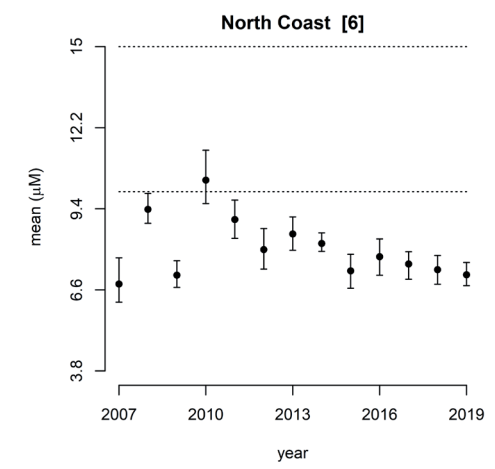
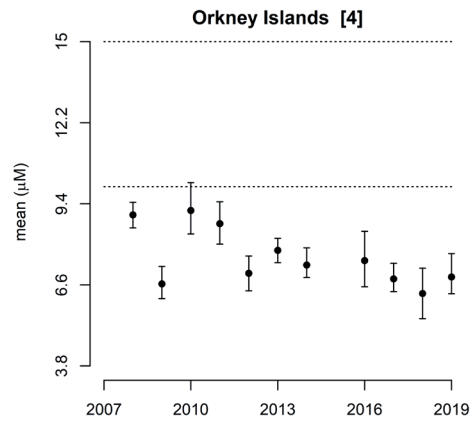
Results

Winter nutrient concentrations have been determined in seawater collected between 2007 and 2019 from coastal and offshore waters. Modelled nutrient concentrations and nutrient ratios have been determined for the eleven SMRs using data from discrete sampling points (Figure 3).

Concentrations were assessed against the OSPAR Ecological Quality Objectives (EcoQOs) for nutrient enrichment in the UK, for dissolved inorganic nitrogen (DIN) (the sum of the concentration of Total Oxidised Nitrogen (TOxN) and ammonia) and the ratio of DIN to DIP. The ammonia contribution to the DIN concentration in offshore water is negligible in Scottish shelf seas and consequently TOxN concentrations can be considered as a proxy for DIN in this assessment.

SMRs encompass both coastal (salinity of 30 - 34.5) and offshore (salinity >34.5) waters. The elevated DIN EcoQOs of 15 μM (offshore waters) and 18 μM (coastal waters) and the coastal background concentration (12 μM), were not exceeded in any SMR. Most regions also had concentrations below the offshore background concentration (10 μM) (Figure 3). TOxN concentrations were stable in all SMRs over the assessment period (Figure 3).

This is in contrast to the nutrient input assessment which showed significant increases for total nitrogen in Orkney and the Outer Hebrides, which indicates this may be a consequence of localised point sources such as aquaculture, with nitrogen not readily available in the wider marine region or dispersion/ dilution in the region.



2017 - 2019

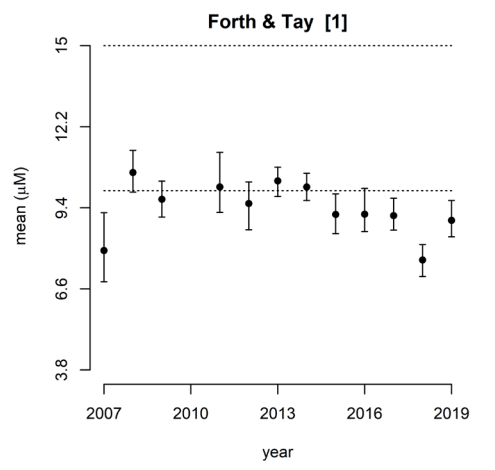
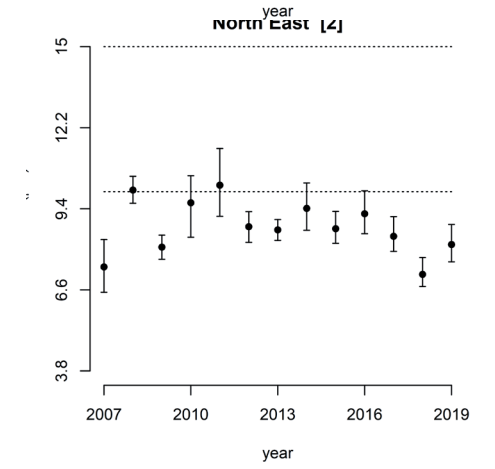
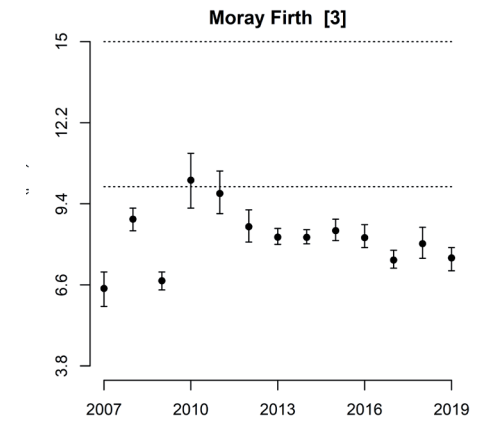
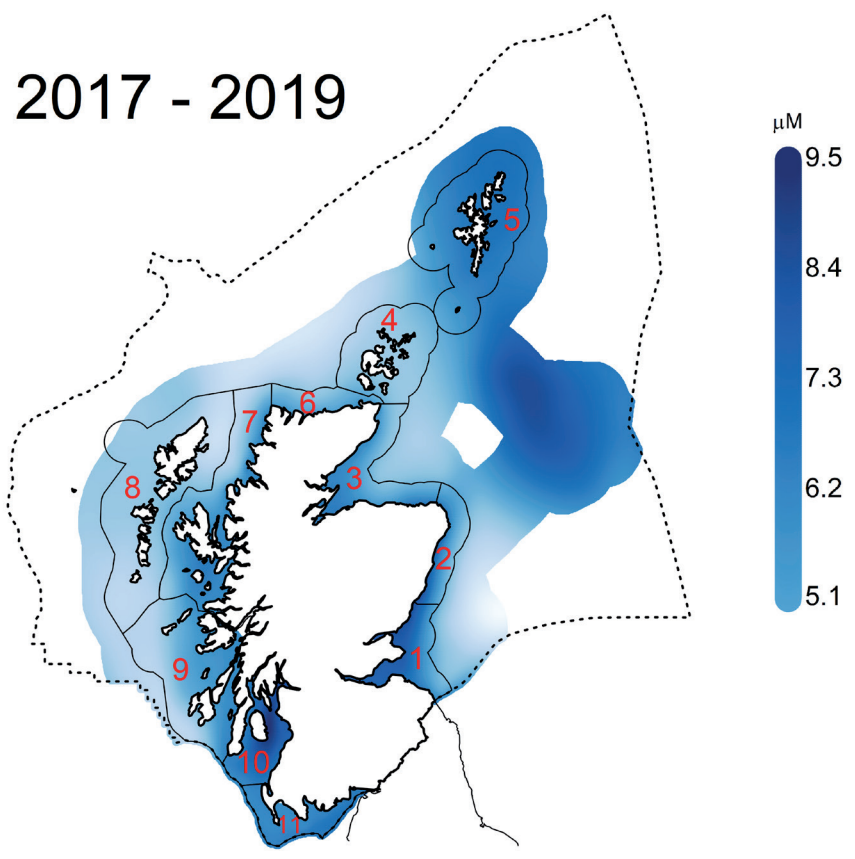


Figure 3: Summary plot of modelled salinity normalised total oxidised nitrogen (TOxN) for winters 2017-2019 (map) for Scottish waters and mean predicted trends over the time series (2007-2019) (graphs). The hashed lines, in the trend assessment, correspond to offshore background (10 μM) and assessment levels (15 μM) for winter offshore DIN concentrations. The Scottish Marine Regions (SMR) are identified as 1-11 corresponding to; SMR 1 Forth and Tay, SMR 2 North East, SMR 3 Moray Firth, SMR 4 Orkney Islands, SMR 5 Shetland Isles, SMR 6 North Coast, SMR 7 West Highlands, SMR 8 Outer Hebrides, SMR 9 Argyll, SMR 10 Clyde & SMR 11 Solway. Mean values were only estimated for a SMR when the predicted values covered at least 80% of the relevant area.

Conclusion

The eleven Scottish Marine Regions have been assessed for winter nutrient concentrations. Discrete water samples were collected in January of each year, between 2007-2019, and the data used to model nutrient concentrations and assess trends. There were no statistically significant increase in the winter nutrient concentrations during the period 2007 to 2019 in any of the regions and concentrations are consistently below the OSPAR EcoQO.

The assessment of nutrient inputs found nutrients were increasing in the Outer Hebrides and Orkney Islands, but this did not translate across to increased winter nutrients in these regions..























Knowledge gaps

Winter nutrient monitoring on the annual CSEMP cruise is well established but does not include collection from all SMRs. The nutrient inputs assessment found increasing nutrients in both the Outer Hebrides and Orkney Island SMRs. Winter nutrient concentrations, in the years assessed, were below elevated ECoQO thresholds in both these SMRs, although it should be noted data coverage for the Outer Hebrides SMR is limited.



















The Orkney Island region was found to have a statistically significant increased N/P ratio which maximised between winter 2010- 2013 before decreasing. This phenomenon is not understood.

Status and trend assessment

The status and trend assessment is for eutrophication and includes, nutrient inputs, winter nutrient concentrations, chlorophyll concentrations and dissolved oxygen concentrations.

Region assessed	Status with confidence	Trend with confidence	Comments
Argyll			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Clyde			The status green box with blue circle is due to a localised issue within the inner Clyde estuary where the dissolved oxygen is failing. Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Forth and Tay			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status. There is a localised issue with the trend assessment due to increasing chlorophyll concentrations, but trend not reflected in other eutrophication parameters.
Moray Firth			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
North Coast			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
North East			The status green box with blue circle is due to a localised issue within the Ythan Estuary which is categorised as being eutrophic. The rest of the SMR is not impacted and not considered to be Eutrophic. Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Orkney Islands			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status. There is a localised issue of increasing nutrient inputs in the region associated with increasing aquaculture. This increasing input is not impacting nutrients across the SMR with no statistically significant trend in winter DIN observed.
Outer Hebrides			There is a localised issue of increasing nutrient inputs in the region associated with increasing aquaculture. This increasing input is not impacting nutrients across the SMR with no statistically significant trend in winter DIN observed. Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Shetland Isles			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Solway			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.
Western Islands			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication status.

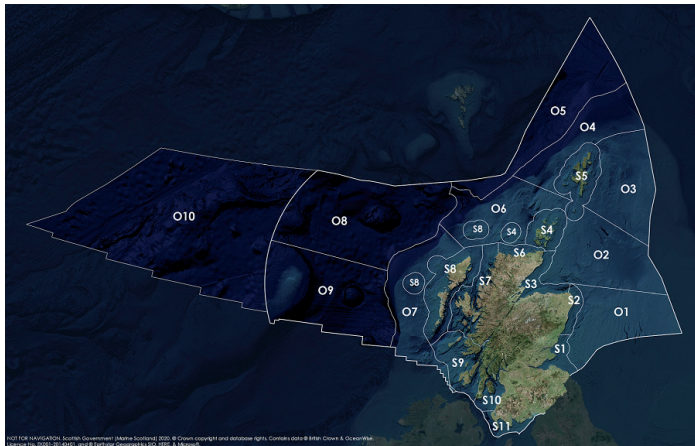
Status and trend assessment legend

Status assessment (for Clean and safe, Healthy and biologically diverse assessments)		Trend assessment (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	Confidence assessment	
	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

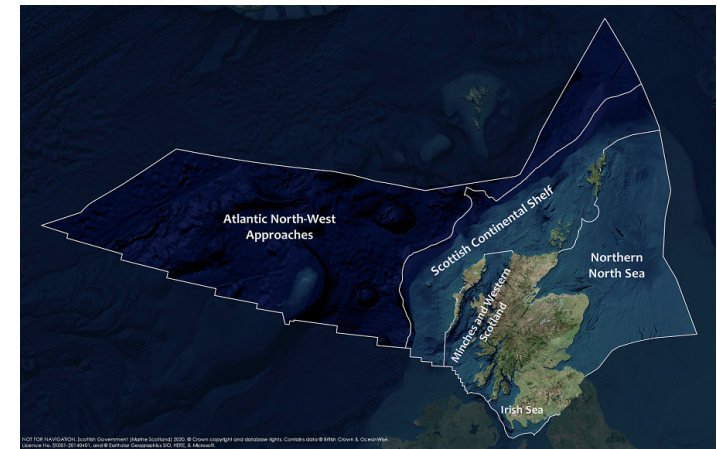


Assessment regions

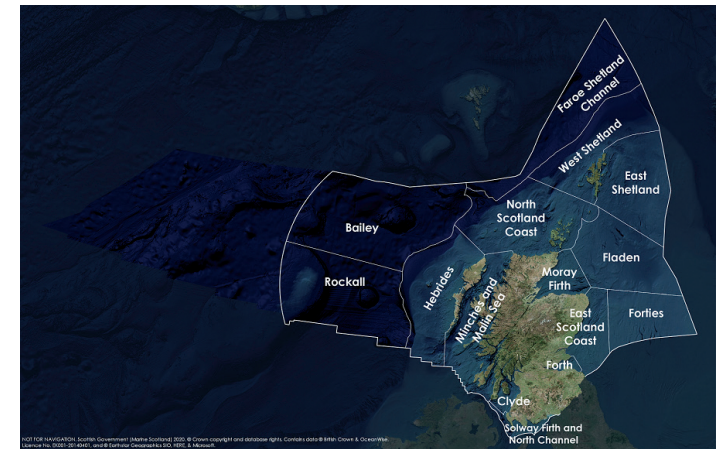


The Scottish Marine Regions (SMRs; S1 - S11) and the Scottish Offshore Marine Regions (OMRs, O1 - O10)

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.