Nutrient inputs in water

Scottish Government
Riaghaltas na h-Alba
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Key message

For the Scottish Marine Regions receiving the highest nutrient inputs (Clyde, Forth & Tay, North East and Moray), there were no significant increasing trends observed (2007-2017) and inputs were lower than the period 1990-2007. North Coast, Orkney Islands and Outer Hebrides do show statistically significant increasing trends although loads were often an order of magnitude lower.


Sea outfall sign

Background

Eutrophication in the marine environment is the excessive growth of phytoplankton in response to enrichment by nutrients (nitrogen (N) and phosphorus (P)) 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. Other pressures, such as climate change, can also result in similar observed effects, often making it difficult to determine causal links.

Inputs of nutrients provide an important indication of nutrient enrichment and the potential for eutrophication. Nitrogen and phosphorus can enter the sea from a number of natural and anthropogenic sources. These include direct discharges (Figure 1) (e.g. sewage, aquaculture etc.), inputs from rivers, land runoff and atmospheric deposition.

The Scottish Environment Protection Agency (SEPA) regulates discharges to the sea and monitors nutrient concentrations in rivers. Data collected from these activities were used to calculate annual inputs of nutrients using the OSPAR Riverine Inputs and Direct Discharges (RID) approach. These were used to assess the relative contributions of anthropogenic activities to nutrient enrichment. These data were analysed in time series to assess the success of management measures aimed at reducing nutrient inputs, such as OSPAR recommendations and a number of EU directives (e.g. Water Framework Directive).

This assessment determines waterborne nutrient inputs into the Scottish Marine Regions (SMRs) and analyse trends since the last Marine Atlas Assessment (Baxter *et al.*, 2011). Atmospheric inputs were not assessed.

For further information on this topic go to: https://marine.gov.scot/sma/assessment/nutrient-inputs-water

Figure 1: An example of marine sea outfall (direct discharge)

Results

There is no status assessment for nutrient inputs into the marine environment as there are no regionally set assessment thresholds. However, the nutrient inputs assessment should be interpreted in conjunction with the other indicator assessments that contribute to the overall assessment of eutrophication.

The highest total loads for both total nitrogen and total phosphorus were generally found in the regions that drained the largest urban areas. These included the Clyde, Forth & Tay, North East and Moray regions. Total loads in more sparsely populated regions were often an order of magnitude lower e.g. North Coast, Outer Hebrides and Orkney Islands.

Trend assessment

For both total nitrogen and total phosphorus from 2007-2017, statistically significant increasing trends exist for the North Coast, Orkney Islands and Outer Hebrides SMRs, whilst a statistically significant decreasing trend exists in the Shetland Islands (Figures 2 & 3). No other statistically significant trends were found in any of the other regions for total nitrogen or total phosphorus.

Examining the nutrient inputs from different sources suggest that increasing trends in the Orkney Islands and the Outer Hebrides are a result of increases in loads from marine pen fish farms which are related to increasing farmed fish biomass in the region (extended results). This is in contrast to the winter nutrient assessment which shows decreasing Dissolved Inorganic Nitrogen (DIN) trends in the Orkney region and no trend in the Outer Hebrides. This suggests increased nitrogen inputs did not translate across to the wider marine regions either because it was not readily available or there was dispersion/ dilution in the region.

The decreasing trend in the Shetland Islands is a result of a steady decrease in loads from marine pen fish farms, which is related to a comparable decrease in farmed fish biomass in the region.

The increasing trend in the North Coast region is related to increasing riverine loads, which whilst statistically significant, still presents the lowest nutrient input of all regions.

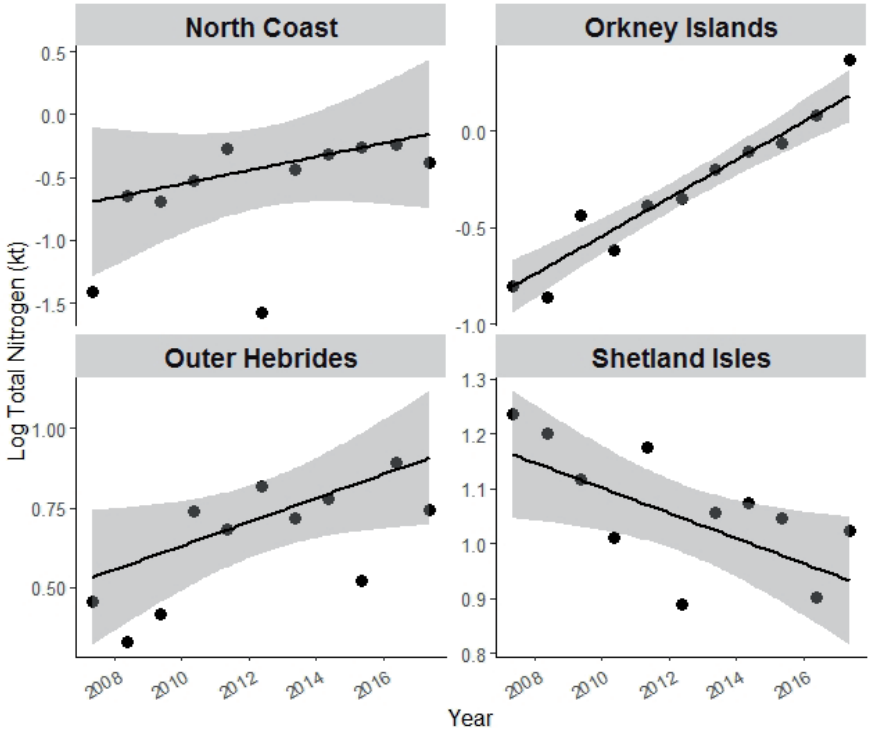


Figure 2: SMRs with statistically significant total nitrogen trends 2007-2017 (grey bands represent 95% confidence interval of Theil-Sen regression models).

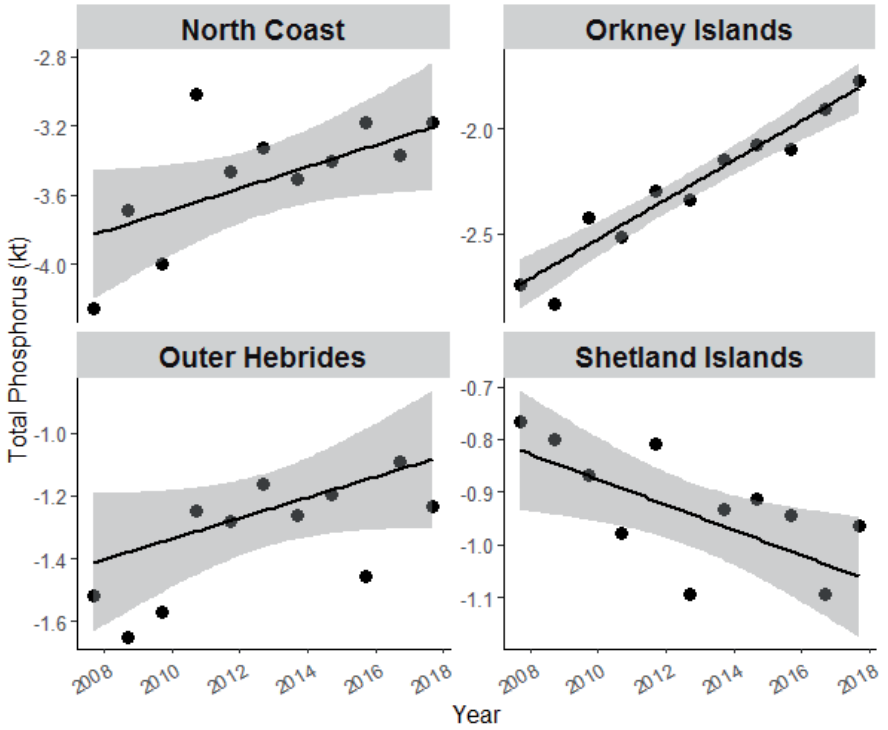


Figure 3: SMRs with statistically significant total phosphorus trends 2007-2017 (grey bands represent 95% confidence interval of Theil-Sen regression models)

Change since Scotland's Marine Atlas (2011)

Although the assessment regions are different between this assessment and Scotland's Marine Atlas (Baxter *et at*., 2011) there are some that are broadly comparable. In regions such as the Clyde, Forth & Tay and North East, total nitrogen and total phosphorus inputs from 1990-2008 (2011 Atlas) are generally higher than in the assessment period of this assessment (2007-2017), suggesting there has been a general decrease in nutrient input since 1990. Reductions in total nitrogen and total phosphorus inputs over this time period are a result of improvements made to wastewater treatment. This aligns with findings from regional assessments such as the MSFD assessment (2019) and the OSPAR intermediate assessment (2017).

This assessment also includes aquaculture inputs, which were not quantified in the 2011 Atlas. Nutrient inputs from aquaculture include the total nutrient load (dissolved and particulate).

Conclusion

In the Scottish Marine Regions receiving the highest inputs, there were no significant increasing trends observed in the period 2007-2017. These regions included the Clyde, Forth & Tay, North East and Moray, where riverine and sewage sources are the most prominent due to higher populations.

The regions where nutrient inputs are lowest are also those that have observed increasing total nitrogen and total phosphorus input trends over the assessment period. These are related to increased inputs of nutrients from marine finfish aquaculture and reflect the biomass of fish grown in these regions in recent years, with the exception of Shetland which had lower overall fish biomass in 2018 than 2008 (see Aquaculture assessment in Productive section).

Knowledge gaps

The dataset used in the assessment was developed following the OSPAR RID principles for regional OSPAR assessments. When aggregated to the scales required by the Scottish Marine Region assessment there were gaps in certain regions, particularly for riverine data. A methodology for determining atmospheric nutrient inputs at the SMR scale needs to be developed so that all inputs of nutrients can be assessed.

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.

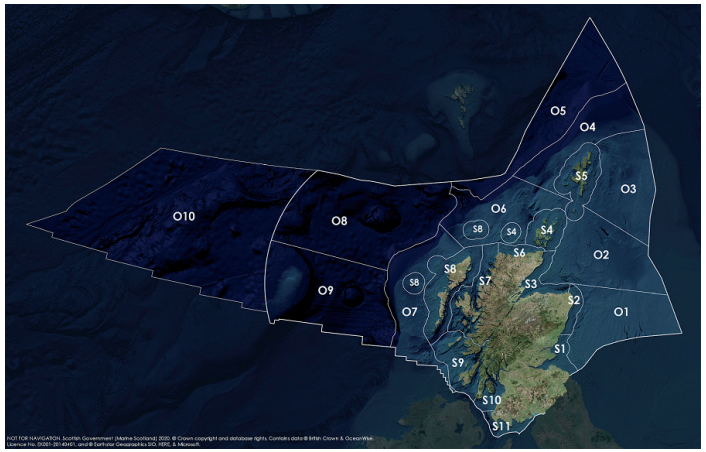
Region assessed	Status with confidence	Trend with confidence	Comments
Argyll			Status and trends have been given a confidence of 2 stars because there is limited dissolved oxygen data available in the region and this has been acknowledged as a knowledge gap in the current assessment of overall Eutrophication 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	**Symbol**	**Confidence rating**
	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

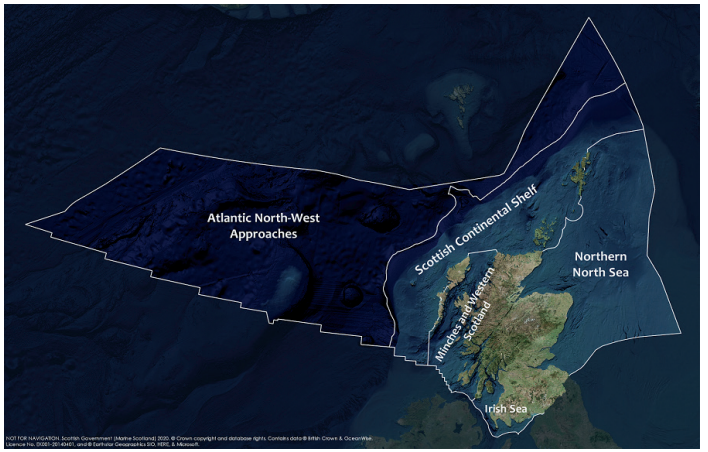
Overal confidence

Assessment regions

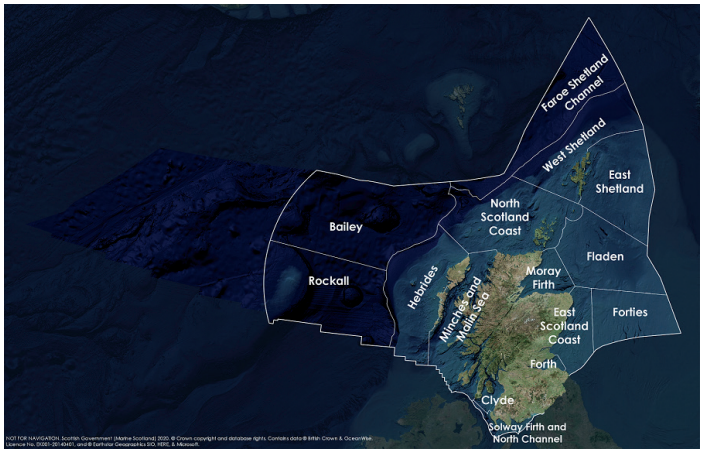


The Scottish Marine Regions (SMRs; S1 – S11) and the Scottish Offshore Marine Regions (OMRs, O1 – O10)

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.

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NatureScot
Scotland's Nature Agency
Buidheann Nàdair na h-Alba

JNCC
Joint Nature Conservation Committee

SEPA
Scottish Environment Protection Agency

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