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Environmental Standards Scotland

Baseline Evidence Review – Water (Strategy and Analysis)

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Version Control

Version	Author	Purpose	Date
1.0	ESS	Baseline evidence review of public sources accessed up to August 2022.	30/09/2002
1.1	ESS	Minor update to clarify risk impacts of NVZs on P21 and the information on marine outfalls on P23.	13/04/2023

Executive summary

This baseline evidence review provides a high level summary of key published information about the current position, recent trends and performance and progress towards relevant targets and standards in the area of water in Scotland.

Background

A series of rapid reviews of key evidence sources were undertaken to support the identification of environmental issues of most concern, where Environmental Standards Scotland's (ESS) proposes to focus its initial analytical work.

Eight reviews were produced, covering the environmental categories of air; biodiversity and ecosystem resilience; climate change; cross-cutting environmental governance; land and soil; population, human health and cultural heritage; resource use and waste; and water. These categories are primarily intended to help Environmental Standards Scotland organise, manage and prioritise its work and are based on those used in the Strategic Environmental Assessment and the Environmental Impact Assessment processes. Considering the evidence within each category provides a structure for assessment.

There will be overlaps amongst these categories and to minimise duplication, topics have been covered under what was considered to be the most relevant category. For example, there is some overlap between this review and the 'Biodiversity and Ecosystem Resilience' review in relation to species and habitat condition in the freshwater environment.

Rapid reviews were undertaken in each topic area, with a narrow scope of identifying key data sources and summarising what they tell us about how the environment is changing in Scotland. The focus was on National or Official Statistics and Annual Reports and their related data, mainly from Government and other national organisations, to obtain a high-level summary of current environmental conditions and to ensure confidence in the quality of the information.

The approach started with the data, considering whether Scotland is on track to achieve its current environmental targets and objectives.

The reviews are not intended to be detailed explorations of individual issues e.g. reasons underpinning the water quality status of any particular river. Similarly, they

are not intended to provide exhaustive lists of relevant legislation. If a topic is not included, it is because it is covered in another review or relevant published data was not found within the scope of the review at this point. However, the topic will still form part of ongoing horizon scanning activity and could be explored in the future with relevant organisations.

Future stages of analysis will consider whether performance trends relate to any issues of compliance with or effectiveness of environmental legislation and scrutinise the detail underpinning trends identified.

ESS' monitoring and analysis work will progress through a series of stages. This will range from horizon scanning to identify high-level areas of concern, through to a deepening analysis and understanding of how things are changing, the causes of this, and how policy and regulatory decisions affect this. All of the monitoring and analysis work will be focused on identifying areas where further investigation or use of ESS' powers may be necessary. It will also support active investigations and help to assess whether the changes that have been made in response to ESS' recommendations or use of powers are having the desired impact.

As the analytical priorities are taken forward, it is likely that some will quickly be identified as not having any compliance or effectiveness issues that merit further analysis or investigation at this stage. These can then be returned to horizon scanning in case an issue arises in the future, and a new issue can be added to the list of those subject to more detailed analysis.

The list of analysis priorities is expected to be dynamic and regularly updated. The evidence reviews, however, are a snapshot in time as of August 2022 and there is no plan for these to be updated on a regular basis.

Summary of key baseline evidence review findings

There have been positive improvements in the state of both freshwater and marine environments in Scotland over the past decade. For example, the number of water bodies classified as being in good condition has increased. There have also been improvements in the level of contaminants in the marine environment. Furthermore, Scotland has met its target to protect 10% of the marine and coastal environment.

However, issues remain. Scotland has consistently missed targets for the condition of freshwater and marine environments. There are also persisting issues around beach litter and declines in marine biodiversity.

A variety of pressures on Scotland's water environment have been identified. Rural diffuse pollution from agriculture, barriers to fish migration and modifications to physical condition have been persistent pressures on the freshwater environment.

Sewage discharge and pollution from pharmaceuticals have been identified as potential pressures, although further work is needed to understand the extent of their impact.

Fishing activity and aquaculture can exert significant pressure on the marine environment through habitat damage, removal of species and pollution discharges.

Climate change is a cross-cutting pressure thought to impact both freshwater and marine environments. Climate change will also increase the risk of water scarcity events as well as the already high risk from flooding.

There is a high level of compliance with drinking water standards in public supplies across Scotland. The level of compliance is slightly lower for private water supplies, but compliance is still high.

It is important to note that a lack of data in some areas, such as for the state of the marine environment and marine protected areas, may limit conclusions.

Conclusions for initial ESS analytical priorities

This baseline review identified a wide range of possible issues for further analysis, including progress against River Basin Management Plan (RBMP) targets, the extent of water scarcity risk, pressures on the marine environment, the effectiveness of marine protected areas and the extent of the impact of sewage discharge into water on the environment.

However, for the purposes of setting out initial analytical priorities, ESS will focus on:

- Sewage discharge into the aquatic environment;
- Developing a better understanding of threats to the marine environment;
- Understanding water quality issues, with an initial focus on progress against River Basin Management Plan objectives.

ESS' proposed Strategic Plan describes how issues will be prioritised for further analysis according to a range of criteria, including:

- Importance – the size and risk of the potential effect on the environment and/or public health; the urgency with which improvement is required;
- Nature and Scope – recent trends in environmental performance; whether the issue of concern appears to be systematic and/or longstanding;
- Neglect – whether there has been action taken on the issue of concern, or further action is planned in the near future; and
- Added-value – the contribution we could make, considering whether other monitoring, oversight or scrutiny bodies are planning to take, or could take, action to address the issue of concern.

The water analytical priorities take account of that scheme and recognise the importance of these issues. For example, the potential impact that threats to the marine environment can have on other aspects of the environment (e.g. biodiversity, flooding), the international importance of the RBMP process and the public's concern around the impact of sewage discharge. They also consider the lack of data on the issues of sewage discharge and pressures on the marine environment, and the missed targets under RBMP. In keeping with the prioritisation process, the contributions of other actors and the added value that ESS can bring to an area will also be considered, in deciding where to focus future work.

Although ESS intends to focus on three issues in the first instance, other issues will be retained on a list for potential future analysis and horizon scanning in line with the stages of monitoring and analysis work set out in the strategic plan.

Water Baseline Evidence Review

1. Introduction

Scotland's rivers and lochs cover 2% of Scotland's land area and contain 90% of the UK's surface freshwater[1]. Scotland's freshwater provides a wide range of services including drinking water, water supply for agriculture and recreational sites.

Scotland also has 21,000 km of coastline, around 12% of Europe's coast. The marine area from the coast to its fishery limits is around six times the size of the land area of Scotland[1]. The marine environment supports a host of services including the fisheries and aquaculture industry, offshore wind power and recreational sites.

2. Methodology

A rapid review of key evidence sources has informed this report. This has focussed on scanning across the topic area, identifying key data sources and summarising what they tell us about how the environment is changing in Scotland and whether environmental targets and objectives are on track to be achieved.

The scope of the work was deliberately narrow and was intended to provide a snapshot of the evidence rather than a fully comprehensive picture. Where ESS' initial assessment of the evidence has identified potential concerns or issues that warrant further scrutiny, more detailed monitoring and analysis will be considered.

The work focussed on published analytical reports and datasets, searching for relevant evidence by:

- using the terms 'water', 'freshwater', 'coastal' and 'marine' sometimes in combination with 'quality', 'protected', 'pressure', 'pollution', 'supply', 'demand' and / or 'resources'.
- having searched for the broad terms above, sometimes specific searches were undertaken for particular topics e.g. 'climate change', 'flooding', 'agriculture' or 'sewage'.
- where necessary these terms were combined with 'Scotland', 'UK', 'EU' or 'International' to search for comparisons with other countries.

These terms were derived from ESS' environmental categories and sub-categories. Specific searches of key organisations' websites were also undertaken, based on knowledge and understanding of those active in the area. For water data this

focussed on SEPA, Marine Scotland and Scottish Government. There is some subjectivity in the choice of terms and organisations which may have an impact and was somewhat mitigated by consulting with key stakeholders on sources.

The focus of the reviews was on National or Official Statistics and Annual Reports and their related data, mainly from Government and other national organisations, to obtain a high-level summary of current environmental conditions with a tight scope which allowed the reviews to be completed in time to inform strategic plan development. Only publicly available information was considered. Individual research reports or grey literature on specific, detailed areas of the topic were not within scope.

Evidence of issues relating to compliance with or effectiveness of environmental legislation was not the focus at this stage. It is envisaged that this will form part of future analysis activity on priority analytical areas.

The approach started with the data, considering whether Scotland is on track to achieve its current environmental targets and objectives in this area. They are not intended to be detailed explorations of individual issues e.g. reasons underpinning the water quality status of any particular river. Similarly, they are not intended to provide exhaustive lists of relevant legislation.

Baseline evidence reviews have been undertaken in each of the ESS Environmental Categories and there are naturally some topics which could fall across a number of reviews. For example, many of the issues relating to species and habitat condition in the freshwater environment have been considered in the ‘Biodiversity and Ecosystem Resilience’ review and this is covered to a lesser extent here.

If a topic is not included, it is because it is covered in another review or no relevant published data was found within scope. However, the topic is likely to still form part of future horizon scanning activity and could be explored further with relevant organisations.

Initial drafts of the evidence reviews were shared with the ESS Board and with key identified analytical stakeholders to provide proportionate checks that no key sources had been missed and no information had been misinterpreted. Going forward into more detailed analytical projects and undertaking further horizon scanning, ESS expects to engage a wide range of experts, including academics and specialist organisations.

3. Baseline evidence for environmental areas

Protected freshwaters & freshwater quality/pollution

The water environment in Scotland includes 3,652 river, loch, estuary, coastal water (within one nautical mile[i,2]) and groundwater bodies. There are also 1,526 protected freshwater areas (bathing waters, shellfish waters, areas protected for wildlife conservation or areas used to supply drinking water).[3]

The EU Water Framework Directive (2000)[4] (WFD) was implemented in Scotland through the Water Environment and Water Services (Scotland) Act 2003[5,6]. This legislation created a system for protecting and improving the condition of the water environment across Europe through River Basin Management Plans (RBMPs). The legislation states that the Scottish Environment Protection Agency (SEPA) must produce RBMPs[7] every 6 years for Scotland's river basin districts (RBDs).

The two RBDs in Scotland are: the Scotland RBD and the Solway Tweed RBD (N.B. Around 70% of the Solway Tweed RBD sits within Scotland, while the other 30% sits in England. SEPA produces the RBMP for the Solway Tweed RBD in collaboration with the Environment Agency in England). RBMPs have been published in 2009, 2015 and 2021.

RBMPs must include information such as a summary of the characterisation of the RBD, details of significant pressures and the impact of human activity on the status of the water environment, the protected areas within the RBD, arrangements for monitoring water status, and the results of the monitoring.[5]

RBMPs also set targets for water quality for surface waters and ground waters, including coastal, lake, river and transitional waters. The targets work towards 'having all feasible and proportionate actions in place by 2027'[8]. The target setting process differs by types of water body.

- Protected freshwaters have targets specific to their condition and type (bathing waters, shellfish waters and wildlife conservation areas). They may also be subject to other legislation beyond the RBMPs.[9]

[i] Included in the freshwater section as the River Basin Management Planning system under the Water Framework Directive includes coastal waters within one nautical mile of the coast.

- Where water bodies cannot be restored to 'good' ecological status (classification process specified in the legislation[6]) without significant adverse effects on the uses of the water body, they are designated as heavily modified bodies (HMWBs). Where water bodies were created by people where no natural water body previously existed, they are designated as artificial water bodies (AWBs). The goal for these water bodies is to achieve good ecological potential, rather than good ecological status. Good ecological potential is the ecological quality that can be achieved without a significant adverse impact on the benefits served by the water bodies, including benefits to environmental interests, such as wildlife conservation.[10]
- For all other water bodies, targets are set for overall condition (classification process specified in the legislation[6]). The 3rd RBMP for the Scotland RBD also gives information and targets for 4 component categories of the overall classification: Water quality, Water flows and levels, Physical condition, Access to fish migration.

While targets are set for overall condition, SEPA also reports data on other aspects of water quality which contribute to the overall condition rating, such as ecological status, chemical status and the components of these, such as pH levels[11].

Reporting under the RBMP system is the main source of data on water quality in Scotland.

Overall status of freshwater bodies

The general trend presented from the data published by SEPA[11],[12] and from reporting under the Environment Strategy for Scotland[13] is that the number of water bodies classified as being in ‘good or better’ condition overall has modestly increased since 2007.

When the first RBMP was published in 2009, 61.3% of surface waters in the Scotland and Solway Tweed (Scotland area only) RBDs were classified as being in good or better condition. In 2020, the most recent assessment, this figure was 64.2%.

The data for groundwaters in the Scotland and Solway Tweed (Scotland area only) RBDs shows that in 2012 75.9% were classified as good and in 2020 84.1% were classified as good[11].

Focussing on the Scotland RBD only (since targets in the Solway Tweed RBMP apply to Scottish and English areas), targets set by RBMPs have been consistently missed, and targets have been revised with each RBMP cycle. See Table 1 below.

Discussions with SEPA indicate that they are aware of this. They note that making progress against the RBMP is difficult because increased levels of monitoring reveal other problems and change the baseline against which they are working to improve. For example, they have increased monitoring of hydro-morphology and fish barriers. They also commented that the level of progress depends not only on improving the state of the environment, but also preventing deterioration, which is often affected by external factors. In addition, they mentioned that there have been revisions to methodologies and standards (e.g. those set by the UK Technical Advisory Group) which has complicated some work under the RBMP system.

The 2021 RBMP sets out that there is still an ambitious programme of work needed to achieve the objectives[8].

Table 1: Targets for all water bodies in Scotland RBD only - % with overall good or better condition[ii,7,11]

Year	**2008**	**2015**	**2020**	**2027**
Actual %	64.8	65.2	68.7	N/A
Targets in 2009	65	71	77	98
Targets in 2015	N/A	N/A	72	88
Targets in 2021	N/A	N/A	N/A	81

Notes

1. Table developed from multiple sources of SEPA data (RBMP reporting and water classification hub) as part of ESS' analysis function.
2. N.B. calculation of actual % in good or better condition includes both surface waters and ground waters, in line with targets for the Scotland RBD.

More information on the state of Scotland's species and habitats can be found in the 'Biodiversity and Ecosystem Resilience' baseline evidence review.

[ii] This has been developed from multiple sources of SEPA data as part of ESS' analysis function.

Location of issues with water bodies

Reporting against the third RBMP published in 2021 also gives information on the state of water bodies according to four more detailed categories. The percentages of surface waters classified as good as better for the four categories in RBMP3 in 2020 in the Scotland and Solway Tweed (Scotland area only) RBDs were: water quality 86.2%, water flows and levels 88.9%, physical condition 90.5% and access to fish migration 88.2%.

For protected waters in the Scotland and Solway Tweed (Scotland area only) RBDs, in 2021 both bathing and shellfish waters had 84 of 85 (99%) at their target objective. However, for wildlife conservation areas, only 165 of 349 (47%) are at their target objective[12].

This review found limited information available on wildlife conservation areas and further evidence would be needed to understand the target objectives and progress towards these.

Within the water bodies in the Scotland and Solway Tweed (Scotland area only) RBDs 41.55% of surface water HMWBs and AWBs were classified as having good ecological potential in 2020.

In terms of the type of water body affected, the main issues with the condition of water bodies in the Scotland RBD are found in rivers (with 41.7% rated below good), compared to other water body categories such as lakes (with 26.8% below good), transitional waters (with 13.2% below good) and coastal waters (with 0.2% below good)[iii,11]. However, it is important to note that there are a larger number of rivers than other types of water bodies.

Further analysis is needed to better understand the geographical distribution of water bodies with different classifications.

It is also important to note that data loss due to the cyber-attack on SEPA means that assessment of Scottish water quality may be limited in some areas.[14]

International comparisons

As part of ESS' initial scoping work on water quality, an initial comparison between the Scotland RBD and other RBDs was conducted. That work found that there is

[iii] These conclusions have been drawn from ESS analysis function work using SEPA data.

variation in the reporting and planning undertaken as part of the RBMP process across Scotland, England, Wales and Ireland. While Scotland RBDs include targets based on the percentage of water bodies to reach overall good or better condition, this is not replicated in the English/Welsh/Irish plans.

The other countries' plans report current status and targets against the components of the overall status rating (ecological/chemical/quantitative status) and often do this separately for surface and ground waters. This means it is difficult to compare detailed progress between the countries' individual RBD plans.

However, JNCC have produced a summary comparing the percentage of surface water bodies with each RBMP classification in the four UK countries[15]. Using data from 2018 and 2019, the data shows that Scotland has the highest percentage of water bodies classified as good or better (63%), followed by Wales (40%), Northern Ireland (31%) and England (16%).

Scotland is also the only country in the UK to have any water body classified as having high classification status[15], with 13.7% of all water bodies in Scotland having high classification status in 2020[12].

In 2018 the European Environment Agency produced an assessment of the status and pressures of European waters[16]. The report found that 74% of ground waters had good ecological status and 89% had good quantitative status. They also reported 40% of surface waters have good ecological status/potential and 38% have good chemical status. Mercury was found to be the most common substance accounting for poor chemical status.

The European Commission has reported on the implementation of the WFD[17]. The most recent report was published in 2021 and found that by the middle of the 2016-2021 RBMP cycle, all member states had made progress in identifying issues and had started implementing measures under the WFD, although with some delays.

The report concluded that progress towards objectives had improved since the previous assessment in 2015. However, there were some obstacles to implementing measures, with the most significant being lack of finance, delays and governance[18]. Indeed 64% of RBDs are yet to secure finance for all relevant sectors[18].

Summary

The condition of both protected and unprotected freshwaters is generally good and has modestly improved since 2009.

There are some potential areas of concern such as the overall condition of rivers (where the proportion in good or better condition is lower than for other water body types), the state of waters in wildlife conservation areas and the status of HMWBs and AWBs. The missed targets for the condition of water bodies under successive RBMPs is another area of concern.

It can be difficult to make detailed comparisons with other countries due to differences in reporting procedures. However, Scotland appears to be performing better than other countries for which there is similar data, with a higher percentage of water bodies reaching good or better status than any country in the UK and the EU average.

Pressures on freshwater bodies

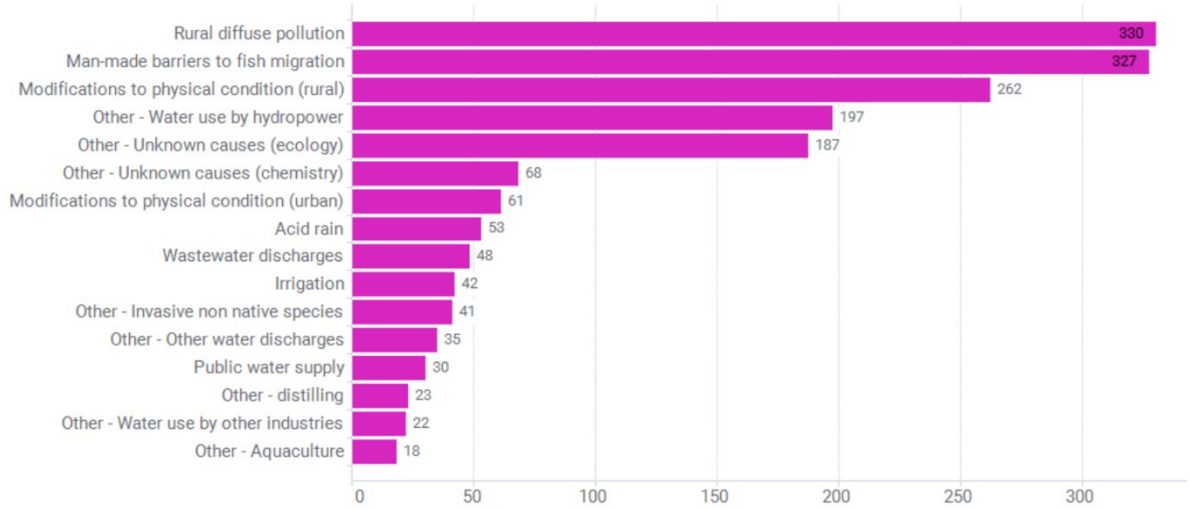
Range of pressures

Pressures on water bodies are reported and monitored through the RBMP system described above. The Controlled Activities Regulations also regulate activities that may impact water bodies such as discharges of wastewater[19]. Other regulations including the Waste Management Licensing Regulations[20] and Pollution Prevention and Control Regulations[21] also apply.

A wide variety of pressures on water bodies from multiple sectors were identified in 2020. See Figure 1 and Figure 2.

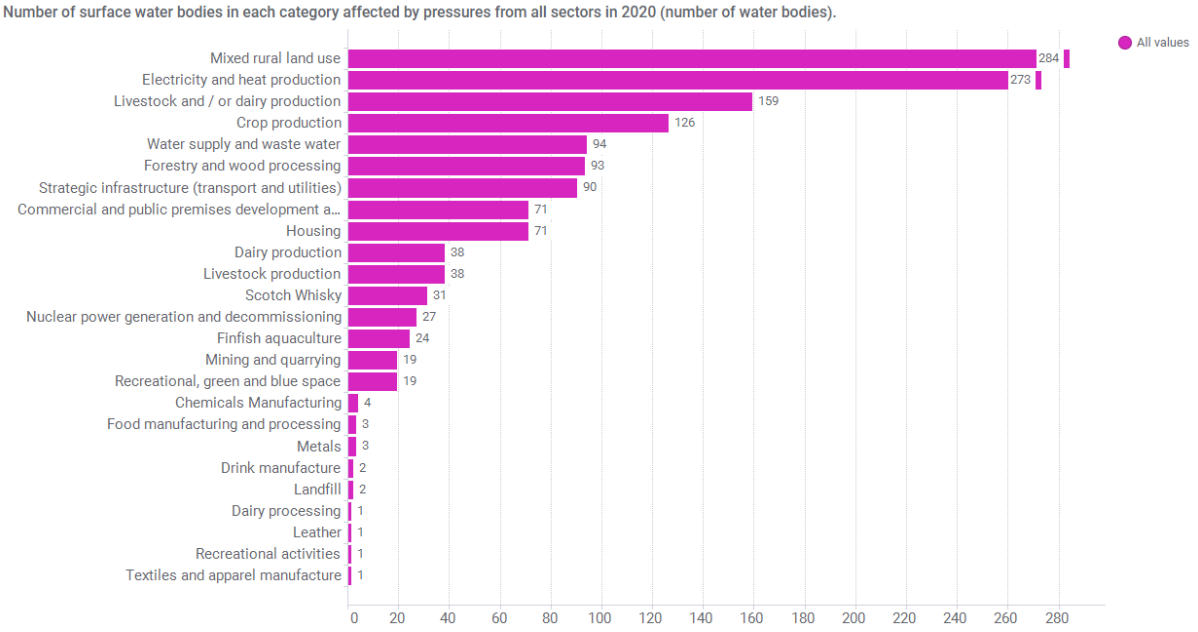
These figures show that the most prevalent pressures on surface waters arise from the key themes of rural diffuse pollution, man-made barriers to fish migration and modifications to physical condition. The sectors responsible for the most pressures are the mixed rural land use, electricity and heat production, and livestock and/or dairy production sectors.

Figure 1: The number of surface waters in Scotland and Solway Tweed (Scotland area only) RBDs affected by each pressure identified in 2020 according to RBMP theme.[12]



Source: SEPA, Scottish Government, The river basin management plan for Scotland 2021-2027 and The river basin management plan for the Solway Tweed river basin district: 2021 update.

Figure 2: The number of surface waters affected by pressures from different sectors in 2020 in both Scotland and Solway Tweed (Scotland area only) RBDs.[12]



Source: SEPA, Scottish Government, The river basin management plan for Scotland 2021-2027 and The river basin management plan for the Solway Tweed river basin district: 2021 update.

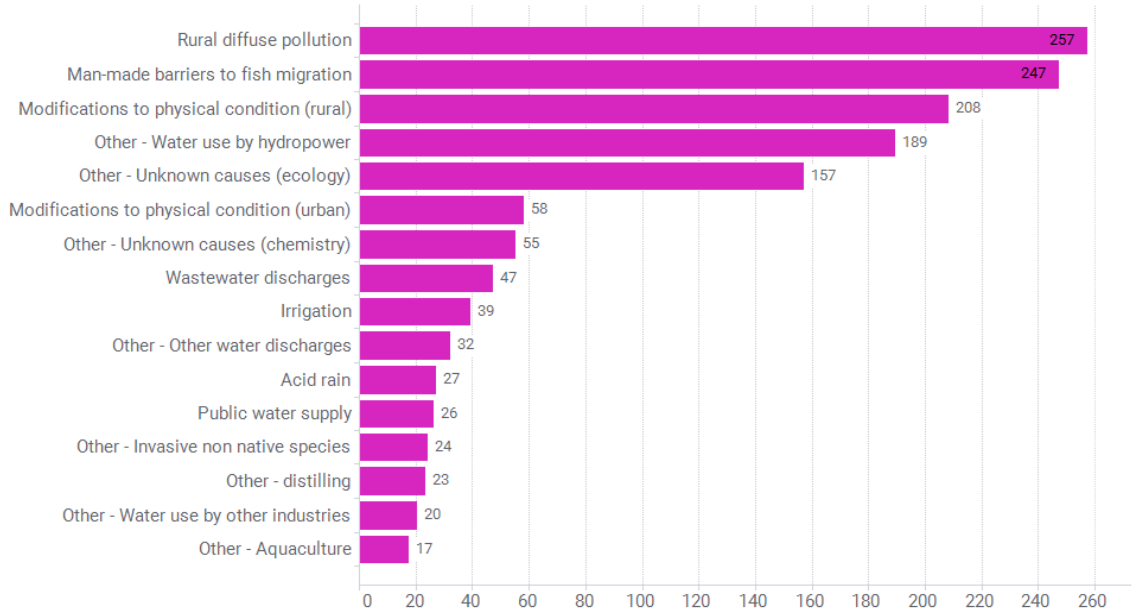
A comparison of pressures over time in the Scotland RBD only is illustrated in Figure 3 and Figure 4 below.

The figures show that the top three pressures on freshwater bodies in the Scotland RBD (rural diffuse pollution, man-made barriers to fish migration and modifications to physical condition) have remained consistent from 2015 to 2020. However, the order of the top three has changed.

In 2015 man-made barriers to fish migration was the top pressure. By 2020 this had dropped to the second most prevalent pressure, with rural diffuse pollution being the most prevalent pressure. Modifications to physical condition moved from second to third most prevalent pressure between 2015 and 2020.

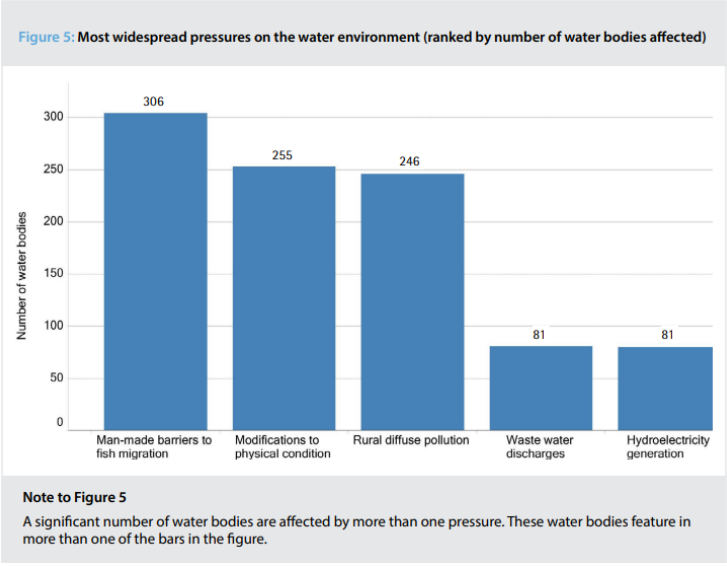
The number of water bodies affected by water use by hydropower and unknown causes (ecology) has increased between 2015 and 2020. Discussions with SEPA reveal that this is due to an increasing number of hydropower schemes being licensed and more data on fish collected respectively.

Figure 3: The number of surface waters affected by each pressure identified in 2020 according to RBMP theme, for the Scotland RBD only[12]



Source: SEPA, Scottish Government, The river basin management plan for Scotland 2021-2027

Figure 4: The number of surface waters affected by each pressure identified in 2015 according to RBMP theme, for the Scotland RBD only[8]



Source: SEPA, Scottish Government, The river basin management plan for Scotland 2021-2027

Pressures have also been identified by other organisations. For example, the not for profit trade membership organisation, Fisheries Management Scotland, identifies the following pressures to freshwater quality:

- barriers to fish passage;
- water quality (e.g. point-source and diffuse pollution, eutrophication);

- instream & riverbank habitat (e.g. loss of vegetation, dredging, non-native conifer afforestation);
- water quantity;
- hydroelectricity (e.g. pollution and changes in hydrology); and
- water temperature.[22]

Pollution from agriculture

Rural diffuse pollution affected the highest number of water bodies in Scotland in 2020, of all identified pressures to the freshwater environment.[12] Rural diffuse pollution is likely to largely originate from agricultural activities such as fertiliser and pesticide applications, livestock grazing and associated manure, and slurry storage and application to land[23,24]. As highlighted in the UK Clean Air Strategy 2019, these activities also impact air quality.[25]

Alongside improvements necessary under the RBMP framework, rural diffuse pollution is regulated through a number of different regulatory frameworks[26,27,28,19], including the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (known as CAR)[19].

SEPA is responsible for authorising activities that may pollute the water environment under CAR[29] and has produced rural diffuse pollution plans for Scotland as part of the RBMP process[30].

The plans involve first directing actions to the catchment areas where action is needed most. Actions within the 2015-2021 plan included awareness raising including stakeholder engagement and training courses for farmers. Further analysis would be needed to understand whether these actions have been effective.

ClimateXChange have previously assessed that the number of freshwater bodies affected by diffuse pollution is decreasing, largely due to the implementation of successful measures as part of the RBMP system[31]. However, this was based on data up to 2014 which showed that 9.9% of groundwaters, 9.4% of rivers, 7.5% of lakes, 4.2% of estuaries and 0.0% of coastal waters were affected.

The most recent data suggests that progress has not been maintained for rivers and lakes with 2020 data suggesting 18.9% of rivers, 11.0% of rivers, 8.2% of groundwaters, 4.2% of estuaries and 0.0% of coastal waters being affected by diffuse pollution.[12]

Agricultural diffuse pollution is the primary source of nitrate in Scotland[32]. The EU Nitrates Directive[33] introduced the requirement to designate Nitrate Vulnerable Zones (NVZs) where concentrations of nitrate in water exceed or are likely to exceed specific levels. The directive also requires an Action Programme to be developed for each NVZ to reduce nitrate pollution.[34] The risk impacts of NVZs largely occur in groundwater. There are currently five NVZs in Scotland.

As agriculture and land use is a major pressure on water quality in Scotland, the upcoming Agriculture Bill in 2023 and the proposals for post Common Agricultural Policy land use incentives will likely be key influences on future water quality.

Sewage discharge

Sewage discharges from mains sewerage are under Scottish Water's remit[35], and so also relate to water supply and sanitation. SEPA also has a remit in this area under CAR[19].

Much of the recent data regarding sewage discharges and combined sewer overflow (CSO) discharges in Scotland has been obtained through Freedom of Information requests from journalists to Scottish Water.

The BBC reported that the number of recorded spills from CSOs in Scotland's rivers and seas has increased by 40% over the last five years, with 12,725 'spill events' in 2020 and at least 120 million cubic meters of waste water[iv] spilled from CSOs between 2016 and 2020[36]. These spills represent overflows from CSOs which are designed to spill during heavy rainfall to prevent sewer flooding in properties[37].

However, this data is incomplete and the BBC suggest that the number and volume of spills is likely to be higher because the list received by the BBC represents a fraction of the operating CSOs. This is likely because Scottish Water is only required to monitor less than 3% of CSOs for pollution, and there is no volume data provided for just over half of the spill events.

These findings should also be interpreted with caution because the influence of other factors, such as weather events, on the number of spills has not been accounted for. Furthermore, while data on the CSOs that the spills originated from is available,

[iv] Scottish Water indicates that all discharges from CSOs must comply with standards set out in environmental licences granted by SEPA. This means that untreated sewage in the waste water discharged is very dilute.

further analysis would be needed to identify which water bodies were affected.[36,38] While useful, the BBC recognise that this data is incomplete so further analysis and quality assurance is required. The Ferret reported a similar finding[39].

SEPA and Scottish Water have recognised that there has been an increase in the frequency with which some CSOs are discharging sewage. They state that this is due to increases in water flows which exceed the flows that sewers were originally designed to handle and blockages from inappropriately flushed items such as wet wipes and sanitary items[37,40].

There are 3,614 CSOs in Scotland, of which it is reported that over 600 are generating unacceptable sewage-related debris and that 24 CSOs have been identified in the 2021 RBMP as impacting the water quality classification of water bodies.

SEPA and Scottish Water reporting also recognises that 80% of CSOs do not have a screen which means that when spills occur they are more likely to introduce sewage debris to the watercourse. Even when the best screens are fitted they are only 90% efficient in preventing sewage debris from being spilled[37,40]. It should be noted that there are circumstances in which it is acceptable for CSOs not to be fitted with a screen, for example where spills are extremely infrequent and the screen would not be cost effective. However, Scottish water have identified 108 priority assets where improvements are required and this includes those where there is inadequate screening[41].

Scottish Water also recognise that there are a number of environmental impacts from sewage discharges from CSOs, such as those relating to microplastics, that are not currently understood[37,40].

Scottish Water have stated, in their route map to improve urban waters which was required under the 2021 RBMP, that they will increase monitoring to cover all CSOs 'that discharge into the highest priority waters' and reduce spills[40]. It is expected that this would involve approximately 1,000 additional monitors on CSOs.

CSO spills can lead to environmental pollution incidents (EPIs), unlicensed discharges into an aquatic environment (river or sea) which must all be reported to SEPA. SEPA and Scottish Water report that there have been 'very few major incidents in the last decade in Scotland, generally fewer than 10 significant incidents and around 200 minor incidents reported each year.'[37,40].

In their 2021/22 annual report, Scottish Water report that there were 282 waste water Environmental Pollution Incidents in 2020/21, up from 194 in 2020/21 but down from 824 in 2010/11[42]. The 2020/21 report noted that while there has been a downward trend in the number of environmental pollution incidents, the speed of reduction has slowed from that seen between 2010 and 2013.

Similar data feeds into the 2022 Habitat condition, natural capital report found that there were 188 sewage discharges into rivers in Scotland in 2019 and that this had fallen from 481 in 2011[43].

Data from 2018 included in Scotland's Marine Assessment[44] shows that there were 826 outfalls from Waste Water Treatment (public and private combined) sources, 214 outfalls from industrial activities (small) and 76 outfalls from industrial activities (large) in 2018 to the marine environment. Some of these outfalls discharge into the freshwater environment and eventually reach the marine environment.

The 2020 Marine Assessment reports that there were more outfalls reported in 2018 than 2011 from Waste Water Treatments and industrial sites due to improvements in data reporting, rather than an actual increase in the number of outfalls. However, it is important to note that the Marine Assessment states that all outfalls are 'subject to strict environmental control and the volumes discharged are small compared with the receiving sea area'[44].

These figures on environmental pollution incidents and outfalls are clearly very different to the 12,725 CSO discharges reported by the BBC since they are measuring different things.

Reviewing the evidence above, there are large differences in the number of incidents reported and the trends in the number of incidents between different sources and these appear to reflect different definitions e.g. of discharges versus environmental pollution incidents. More research would be needed to fully understand which data is most accurate and appropriate, to determine the actual trends and to quantify the impact of sewage discharges on the environment.

In the third RBMP cycle, SEPA notes that it will be working with Scottish Water and private sector operators to 'deliver improvements as required at 40 wastewater treatment works' and 'deliver improvements as required at 24 unsatisfactory intermittent sewage discharges' to address impacts on water quality. This suggests that there were potentially 24 areas of particular concern related to sewage

discharge though further exploration would be required to understand how these have been selected.[8]

Pollution from pharmaceuticals

Pollution from pharmaceuticals, or medicines, entering the water environment can impact freshwater environments. For example it may impact the growth, behaviour and reproduction of aquatic life. It may also contribute to antimicrobial resistance[45].

The One Health Breakthrough Partnership[46] involves national and regional stakeholders with the aim of addressing pharmaceutical pollution. It oversaw a Centre of Expertise for Water project to produce a baseline assessment of the levels of pharmaceuticals in Scottish waters[47]. This found that eight substances (ibuprofen, clarithromycin, erythromycin, diclofenac, EE2, metformin, ranitidine, and propranolol) were identified as posing a high ecotoxicological risk in inland surface waters; three substances (clarithromycin, erythromycin, and ciprofloxacin) were identified as posing a high risk for antimicrobial resistance.

However, their monitoring data was focussed on pollution from wastewater treatment plant, upstream, downstream influents and effluents and some hospitals, with no data on other potential sources such as agricultural, aqua-cultural, landfill or manufacturing discharges. In addition, monitoring gaps mean that there was no data available for over half (18) of the local authority areas and for 367 of Scotland's catchments. Gaps were particularly prevalent for the Highland region and more rural areas[47].

Scottish Water and SEPA are involved in a partnership project called the Chemical Investigations Project (CIP) Scotland. The second phase of that project ran from 2015 to 2020 and 'identified and explored the chemicals of concern, their sources and concentrations leaving the sewerage system and proposed how those of concern should be addressed in the most sustainable way'.[48] Scottish Water advise that the reason for the lack of data in 18 authorities mentioned above is that waste water treatment works in these areas had high dilution and therefore low risk so were not sampled as part of the CIP2 scheme.

Since the CREW baseline assessment, a data tool has been developed to visualise the levels of pharmaceuticals in Scottish waters[49]. Further analysis of this would be needed to better understand the impact on the environment.

Climate change

Some specific evidence regarding the impact of climate change on lochs and reservoirs was recently published by Scotland's Centre of Expertise for Waters[50], and highlighted by the Scottish Government[51].

The research showed between 2015 and 2019, 97% of Scottish lochs and reservoirs monitored increased in temperature with 9% of these warming by more than 1°C per year. These rising temperatures could lead to increased risk of harmful algal blooms, which could restrict the use of lochs and reservoirs for recreation and water supplies.

The researchers make a series of recommendations to address the issue, including adopting an integrated catchment-based approach for setting water quality targets and planning interventions in Scotland's lochs and reservoirs.[50]

Furthermore, ClimateXChange's assessment (based on 2007/08 data) of the indicator of the abundance of the climate sensitive species Arctic charr in freshwater lochs showed as decreasing. This suggests that climate change is impacting species within freshwaters as Arctic charr are cold water specialists and cannot move habitat in response to changing conditions due to their position in lochs.[52]

This indicator was used as part of the monitoring for the first Scottish Climate Change Adaptation Programme but does not appear to be part of the monitoring and evaluation indicators for the second. It is expected that the Scottish Government will monitor the framework for the adaptation programme in response to criticism from the CCC and provide an update in their 2023 report to Parliament on progress[53].

The Climate Change Committee's 2021 climate risk assessment[54] for Scotland also concluded that there is a high risk of an impact of climate change on freshwater, coastal and marine habitats and species. They highlight the following risks where more action is needed:

- Changing climatic conditions and extreme events - including higher water temperatures (which could increase the rate of biological and chemical processes such as algal growth, influence salmon migration, and lead to the loss of species), flooding, water scarcity and phenological[v] shifts

[v] The timing of a periodic biological phenomenon in relation to climatic conditions.

- Pests, pathogens and invasive species – these are likely to increase with climate change leading to increased competition with native species, introduction of disease and habitat alteration[54]

International comparisons

Pressures reported under the RBMP system

There are 14 RBDs in England and three in Wales (with one overlapping with England) each with their own RBMP and assessment of pressures. Further analysis is required to determine the most prevalent and trends in the types of pressures faced by water bodies in England and Wales.

In 2021, the Environment Agency reported that Nitrate Vulnerable Zones (NVZs) cover around 55% of the land in England[55]. It is difficult to make a direct comparison with Scotland as the Scottish Government have not published an estimate of the percentage of total land area covered by NVZs, and have not published updated NVZs for 2021. However, a visual review of the NVZs maps for Scotland[56] suggest that a much smaller area of land in Scotland is covered by NVZs than in England.

In 2018 the European Environment Agency produced an assessment of the status and pressures of European waters[16]. The report found that the main pressures on surface water bodies were hydromorphological pressures (affecting 40%), diffuse sources (38%; particularly from agriculture), atmospheric deposition (38%; particularly of mercury), point sources (18%) and water abstraction (7%).

In 2021 European Commission reported that agriculture had been reported to be one of the main reasons why water bodies had failed to reach good status under the WFD in the EU[18]. Specifically, pressures relating to diffuse pollution from nitrates and pesticides and water abstraction were reported. They reported positive trends in wastewater treatment and priority hazardous substances. They also acknowledged the need to adapt to increasing pressures from climate change, such as diffuse pollution, flow diversion and physical alteration.

Sewage discharge

Sewage discharges into water have been found to occur regularly in England[57] and Wales[58]. Indeed the activist group Wild Justice have launched a judicial review against the England and Wales water regulator, Ofwat's failure to monitor and take enforcement action against water companies discharging sewage into freshwaters[59].

In addition, The Office for Environmental Protection is currently conducting an investigation into the roles of Ofwat, the Environment Agency and the Defra Secretary of State in the regulation of CSOs in England[60]. A joint statement from the UK Chief Medical Officer, Ofwat Chair and Environment Agency Chair also recognised that wastewater companies need to act to ensure harmful substances are not discharged into waterways due to the potential impact on human health.

Using their Safer Seas & Rivers Service[61] Surfers Against Sewage have monitored sewage discharges into English and Welsh waters. Their 2021 publication[57] reported that in 2020 sewage was discharged into rivers and seas over 400,000 times. In terms of notifications from water companies about such incidents, they found that between 1st October 2020 and 30th September 2021, 5,517 sewage discharge notifications were issued by water companies, with 3,328 of these issued within bathing season (15th May – 30th September). Their analysis shows that Southern Water has the worst performance of the water companies. However, it is important to note that some of this data is collected by citizen science, and Surfers Against Sewage are an activist group, so data should be interpreted with caution.

The Chemicals Investigations Programme is an overall national assessment of the risks posed by chemicals in wastewater discharges in England and Wales[62]. The most recent assessment (initial results for 2015-2020) found that water quality of rivers upstream is often poor such that wastewater discharges into them often do not substantially affect water quality downstream of the discharge. It concluded that the principal source of contaminants found in rivers is from domestic sources and that some contaminants are so prevalent that they can be considered ubiquitous. However, it did find evidence of decreases in contaminant concentrations since the last assessment in 2013[63]. CIP2 Scotland sampled for 51 substances agreeing an approach for each with SEPA and identified that 35 require no further action.

A recent report from the Welsh Senedd found that there were over 105,000 sewage discharges recorded from 2,041 storm overflows in 2020, which the report says in an unacceptable level[58]. This figure also does not include unpermitted discharges or those which are not monitored.

With regards to discharges from CSOs, Scottish Water states that ‘performance in Scotland is slightly below the England and Wales water company average but substantially better than the worst performing English and Welsh companies’[40].

However, the Habitat extent and condition, natural capital, UK report 2022 found that overall, in Great Britain there has been 34% decrease in the number of pollution incidents from discharges or escapes of contaminants into rivers between 2011 and 2019[64]. In England, there was a decrease from 2,596 incidents in 2011 to 1,912 incidents in 2019 and in Wales from 239 to 94 over the same period[43]. A decrease in the number of incidents in Scotland (481 to 188) is also reported.

As with the data in Scotland, various sources of data show a mixed picture of the state of sewage discharges in the UK. It is likely that the disparities in the data are due to different definitions of sewage discharge. Further work is required to examine which data is most meaningful and which should be used in any further work.

There has also been international recognition of the pressures of climate change on freshwater bodies[65,66].

Summary

There are a variety of pressures affecting the freshwater environment in Scotland. The pressures reported to be affecting the most water bodies in Scotland are rural diffuse pollution (which likely mostly originates from agriculture), man-made barriers to fish migration and modifications to physical condition. These pressures have remained in the top three since 2015. However, it is thought that the pressures from some sources, such as from diffuse pollution, are decreasing due to action under the RBMP framework.

Sewage discharge has been identified by a few sources as a significant and increasing pressure on the freshwater environment. However, further analysis is needed to better understand the significance of the impact. There is also some limited data to suggest that pollution from pharmaceuticals, potentially linked to sewage discharge, may be affecting the freshwater environment.

Climate change is likely to be an increasing pressure on the freshwater environment. For example, through temperature rises and increases in invasive species.

Similar pressures have been reported on EU waters, particularly around diffuse pollution from agriculture. Sewage discharge has also been identified as a potential issue for the freshwater environment in other UK countries.

Flooding

Assessment of risk and trends

According to the 2018 National Flood Risk Assessment (NFRA)[67,68], around 284,000 homes (1 in 11), businesses and services (1 in 7) across Scotland at risk of flooding from rivers, surface water and the sea. That is more than twice as many that were identified in the 2011 NFRA and 2015 Flood Risk Management Strategies. However, the large increase in properties at risk is likely due to major advances in how properties at risk have been identified, not because the physical risk has changed. There are a variety of sources of flooding including rivers, coastal and surface waters.

The Centre of Expertise for Water summarised the extent of coastal erosion in Scotland in 2021 and the subsequent impact on flood risk[69]. They concluded that coastal erosion coupled with sea level rise means that more frequent flooding and damage to assets is likely. Specifically, under a high emissions climate change scenario, if no action is taken, they estimate that £1.2 billion of assets are likely to be at risk of erosion, increased flood risk and loss of services by 2050.

The NFRA also identified 235 Potentially Vulnerable Areas, where significant flood risk exists now or is likely to occur in the future. Around 90% of Scotland's flood risk is contained within Potentially Vulnerable Areas. [68]

Flood risk maps have been developed to view the location of areas potentially at risk of flooding.[70]

Impact of flooding

Flooding can have a wide ranging impact on the areas and communities it affects.

Estimates of the cost of flood damages to property in Scotland vary from £200 - £250 million per year[71] though these estimates may not be up to date. However, there is a lack of data to fully estimate the impact of flooding on people and the environment[71].

After severe flooding in North-East Scotland during the winter of 2015/16, the Centre for Expertise for Water produced a report to understand the impact of this on people and communities[72]. It found that the flooding had a large impact on people, communities and businesses.

For example, in the first year, people faced issues associated with long-term use of temporary accommodation, unforeseen costs and upset/anxiety associated with flood-related experiences and communication with insurance companies. In the longer term (more than three years after the flood), people faced issues with securing home insurance, installing appropriate home protection and emotional and physical wellbeing arising from the flooding. Children, older people, those living alone and those with pre-existing stressful life circumstances were found to be more vulnerable at all stages of the study.

Local businesses were also financially affected by the flooding. The report also made recommendations on how these negative effects could be mitigated in future including better preparation, clearer communication of warnings and better publicised grants.

Therefore, there are a wide range of long-lasting effects of flooding on people, communities and the economy.

Pressures on flood risk

Climate change is likely to significantly increase flood risk in Scotland. With the effects of climate change modelled to the 2080 UK Climate Projections 2009 (UKCP09) High Emissions scenario[vi,73], an additional 110,000 homes, businesses and services are expected to become at risk across all sources of flooding in Scotland (a total of 1 in 9 homes and 1 in 6 business and services).

Compared with the current level of flood risk, this represents a 90% increase in the number of properties at risk of coastal flooding, 40% increase in the number at risk for river flooding and 25% for surface water flooding.[74,68]

Other factors influencing flood risk include planning and land-use, drainage design, the extent of hard (rather than porous) surfacing in urban areas and the use of river catchment management to reduce flood risk[71].

[vi] The UKCP18 projections are models of how climate change will affect the UK including the land and water environment. There are three different models which are based on three different scenarios of global greenhouse gas emissions.

Managing flood risk

Flood Risk Management Plans are the system through which SEPA aims to reduce the effects of flooding on communities, however multiple organisations are responsible for the plans.

Scotland has been divided into 14 Local Plan Districts. A plan has been prepared for each district.[75] The final plans are due to be published in 2022, for the period between 2022 and 2028. Flood plans can include a variety of actions such as building flood walls or creating green corridors to allow water to flow[76].

Landowners are also responsible for managing some aspects of flood risk, such as protecting their property from coastal erosion[77].

There are a variety of other Scottish Government policies, projects and external agencies working to manage flood risk.[78]

International comparisons

According to a preliminary flood risk assessment for England published in 2018, at least 1 in 6 properties is at risk of flooding in England[79] (cf. in Scotland currently 1 in 11 homes and 1 in 7 business are at risk[68]). The report also identified 116 areas that are at significant risk of river and sea flooding and notes the likelihood that climate change will increase the frequency and severity flooding events in the future.

Similar findings regarding the risk of climate change to flood risk were also reported in a 2013 European Environment Agency (EEA) report[80]. In their 2020 report, the EEA again emphasised the impact of climate change on flood risk but also highlighted that their initial analysis of flood risk management plans showed that flood risk in Europe is decreasing and many countries have plans to improve[81].

Summary

There is significant risk from flooding across Scotland with 1 in 11 homes and 1 in 7 business and services across Scotland estimated to be at risk.

Flooding events have a large and lasting impact on the people, communities and businesses affected. However, the magnitude of the impact has not been quantified.

The risk of flooding events and their severity is likely to significantly increase due to climate change, a prediction which also applies across Europe. Flood risk management plans and other schemes are being implemented to tackle this.

Water resources

Scottish Water provides the public water supply, whilst all other supplies are private and managed by owners or users.[82] Scottish Water has statutory duties both to provide adequate wholesome water supplies and to secure efficient and sustainable water use.[83]

Drinking water standards are set by The Public Water Supplies (Scotland) Regulations 2014, which are in line with European Community requirements.[84]

The Drinking Water Quality Regulator for Scotland (DWQR) regulates the quality of water supplied by Scottish Water, ensuring that drinking water supplies meet the requirements of The Public Water Supplies (Scotland) Regulations.[82]

Drinking water quality

Of the 136,455 water quality tests taken by Scottish Water to represent water at consumers taps in 2021, 99.92% complied with standards. DWQRs assessment in 2021 suggests Scottish Water had a high level of compliance with standards.

The number of events which may affect water quality or customer satisfaction reported by Scottish Water in 2021 was 855. This is higher than in 2020 (650) but similar to 2019 (837). A total of 31 of these were of a more serious nature, similar to 2019 and 2020 (both 29)[85] while 2 were major incidents where there had been none in 2019.[85]

In 2021, DWQR highlighted that it was especially concerned about the number of incidents where failure of part of a treatment work was a causal factor. In 2019 and 2020, the biggest concern had been incidents where human error was a causal factor.

While the majority of people in Scotland rely on public water supplies (approximately 97% of the population), which are the responsibility of Scottish Water[86], some rely on private water supplies. Private water supplies are the responsibility of the owners and users but are still regulated by the DWQR[87] and the Private Water Supplies (Scotland) Regulations[88].

In its 2020 annual report, the DWQR report that of the 26,298 tests carried out, 91.0% complied with the standards. This is a slightly lower level of compliance than public supplies[87]. However, it is important to note that only 38% of regulated private

water supplied registered with local authorities were sampled in 2020 due to pandemic restrictions[87].

Water demand

As part of its climate change indicators on resilience and resource use, ClimateXChange have published indicators of the levels of domestic and non-domestic water use. Using data from the Water Industry Commission for Scotland, ClimateXChange report that in 2017/18, the total water volume used by households was 904 megalitres per day, amounting to 153 litres per person per day.

There has been no clear trend in household water use between 2008/9 and 2017/18 with per capita water consumption remaining relatively stable[89]. For non-domestic water use, it reports that there has been a sustained decrease in the annual average between 2008/9 and 2016/17. For 2016/17 394 megalitres were delivered per day[90].

ClimateXChange report that Scottish Water have been trying to encourage more sustainable water use behaviours in households and business to reduce water demand[90,91].

Pressures on water supply

While Scotland is a relatively wet area of the UK and Europe, recent dry periods have led to water scarcity events. The frequency of these is likely to increase due to climate change. This will influence water availability for drinking water, agriculture and ecosystems, and may mean that Scotland struggles to meet demand.[91] Water scarcity is likely to be unevenly distributed across Scotland with the North East likely to be at greatest risk[92].

SEPA regularly publish water scarcity reports between May and September covering the current risks to water scarcity across Scotland[93,94]. Further analysis of these reports would be needed to determine whether there have been any significant trends in the water scarcity situation in Scotland over time.

SEPA's March 2022 Water Situation Report reported that Summer 2021 was particularly dry but there was relatively good recovery of water resources over the Autumn and Winter in most areas. However, groundwater levels in the east of the country have recently been low and are currently very low for the time of year in Angus. Without above average rainfall through spring and summer there is a risk of seeing water scarcity in Angus and parts of the east of Scotland.[95]

SEPA have developed a National Water Scarcity Plan to help deal with water scarcity events.[96] In additions, measures are in place under the River Basin Management Planning system to mitigate some of these effects.[8]

Other pressures on water supply and quality such as from contamination are discussed elsewhere in this review.

International comparisons

In England and Wales, the Drinking Water Inspectorate assess the quality of drinking water[97]. Their report covering drinking water quality from 2017-2019 found that 99.95% of samples taken met the regulatory standards in both England and Wales[98]. This is the same level of performance as found in Scotland.

According to a report by the European commission covering 2011-2013 of compliance with the Drinking Water Directive found that most countries, including the UK, were compliant[99].

The Environment Agency publish regular reports on the water situation in England. However, further analysis would be required to understand whether there have been any significant trends over time[100].

A 2021 report by the European Environment Agency found that around 20% of the European territory and 30% of Europeans are affected by water stress during an average year, with droughts costing over EUR 9 billion and impacting a range of ecosystems. Water stress is not a permanent issue for most areas and often occurs occasionally and in specific areas. Climate change is expected to increase the frequency of water stress and drought events[101].

Summary

There is a high level of compliance with drinking water standards in public supplies across Scotland. The level of compliance is slightly lower for private water supplies, but compliance is still high. Similarly high levels of compliance with standards are also found in Europe.

There has been no clear trend in demand from domestic water supplies over the past ten years but non-domestic demand has decreased. However, climate change will increase the frequency of water scarcity events and may put pressure on water supplies in Scotland, the UK and Europe.

Marine and coastal water quality/pollution

Overall status of the marine environment

The UK Parliament is responsible for legislating for Scotland's offshore waters[102], and does so through the Marine and Coastal Access Act 2009[103].

The Scottish Parliament legislates for Scotland's inshore waters through the Marine Scotland Act (2010)[104]. The act provided a framework to balance the competing demands on Scotland's seas and coastal areas. The main measures included a duty for public bodies to protect and enhance the marine environment, a new statutory marine planning system, a simpler licensing system, improved conservation and enforcement powers for licensing and conservation[105].

The Marine Scotland Act was implemented through the development of Scotland's National Marine Plan, published in 2015[102,106,107,108]. An agreement between the Scottish and UK Government means much of this plan also applies to offshore waters. The plan also gives consideration to EU Directive 2014/89/EU[109] - Maritime Spatial Planning, and also adopts the strategic objectives of the EU Marine Strategy Framework Directive[110] to achieve Good Environmental Status, according to 11 descriptors[102], in addition to other strategic objectives.

The UK Marine Strategy[111,112] also adopts these Good Environmental Status objectives[113]. The Scottish Government has also published their Blue Economy Vision for Scotland outlining six environmental social and economic outcomes to achieve by 2045[114].

A progress report against the Good Environmental Status targets as part of the UK Marine Strategy published in 2019 found that 11 of the 15 targets were missed by the UK[113]. The targets achieved were those relating to eutrophication, hydrographical conditions, contaminants and contaminants in seafood. The targets partially achieved were those relating to cetaceans, seals, pelagic habitats, food webs and underwater noise. The targets not achieved were those relating to birds, fish, benthic habitats, non-indigenous species, commercial fish and marine litter[115].

The most recent assessment of the state of Scotland's marine environment was the Scottish Marine Assessment 2020[116]. The results of this have been used to evaluate the effectiveness of the National Marine Plan[117,108].

The Marine Assessment 2020 updated Scotland's Marine Atlas 2011[118] and presented similar findings. Headline findings from the 2020 assessment were:

- There has been progress in improving the state of Scotland's seas, particularly in relation to contaminants. However, some local concerns remain, for example in the Clyde.
- There are mixed pictures for marine mammals, birds, fish and marine litter and there are signs of change in plankton.
- There are increasing pressures associated with non-indigenous species, climate change and ocean acidification.
- Limited data restricts the ability to make firm conclusions about the state of the marine environment in all areas.

While these conclusions are correct at the time of publication, discussions with Marine Scotland have revealed that the methods of assessing the state of the marine environment in Scotland, particularly those relating to levels of contaminants, will be revised before the publication of the OSPAR Quality Status Report (QSR) in 2023. This may have implications for conclusions on the state of the environment.

Furthermore, it is important to note that there is likely to be insufficient data in this area, limiting conclusions. The Scotland Marine Assessment 2020 report highlighted that there are insufficient data to allow detailed assessment at the scale of the Scottish Marine Regions and Offshore Marine Regions.[116] Furthermore, Hough (2022)[119] concluded that data on chemical pollution, marine litter, radiation and invasive species are often incomplete and inconsistent meaning they are unsuitable for undertaking trend-based analyses.

More detailed findings related to specific aspects of the marine environment are explored below. The impact of climate change is also discussed in the 'Pressures on the marine and coastal environment' section.

Pollution and litter

In relation to pollution and litter, Scotland's Marine Assessment 2020[120] reported that:

- Overall, concentrations of contaminants and their biological effects are decreasing, but some concerns remain.

- The environment and the public are thought to be adequately protected from authorised disposal of radioactive waste as doses are significantly less than the legal limit.
- Marine litter remains an issue, but there have been improvements in some areas.
- Water quality in coastal bathing waters has steadily improved since progress against the 2006 EU Bathing Waters Directive was first reported in 2015.
- In contrast to freshwater environments, eutrophication is not an issue, however there is limited data on dissolved oxygen to support this conclusion.
- Improvements to data availability are needed.

As part of the monitoring framework for the Environment Strategy for Scotland, the Scottish Government report progress against indicators for Clean Seas, beach litter and plastic litter ingested by seabirds[121].

- The Clean Seas indicator reports the percentage of biogeographical regions with acceptably low levels of chemical contaminants. Contaminants monitored include cadmium, lead, mercury, PAHs and PCBs and are measured in biota (fish and shellfish) and sediment. Monitoring is done in three regions the Northern North Sea, Minches and Western Scotland, and Irish Sea (Clyde & Solway). 2021 data shows that there is a consistently high percentage of acceptable regions reported, 90% were acceptable in 2015 and 2016 and this rose to 93% in 2017 and has remained stable until 2019. However, Marine Scotland advise that the clean seas indicator will be undergoing major revision in the next year (to align with the results from the OSPAR QSR to be published in 2023). The revised version should be more sensitive to change.
- The Beach Litter indicator reports the number of litter items per 100 metres of beach surveyed in six coastal areas of Scotland (Clyde, Orkney, Moray Firth, East Coast (North), Forth and Forth (harbours)). The 10 years prior to 2017 showed decreases overall in the amount of litter found on beaches, especially with the numbers of plastic bags and bottles found. However, there were increases in some types of litter such as sanitary items and smoking related debris. Harbours in the Firth of Forth have the highest total litter loading of any region, followed by the Clyde, and the highest proportion of sanitary items (nearly 50%), and this is increasing. However, it is important to note that

monitoring is limited with infrequent surveys and complete gaps on the West and North coasts and Shetland.[122]

- The Plastic litter ingested by seabirds indicator shows the percentage of fulmars, a species of seabird, exceeding a level of 0.1g of plastic in their stomachs. The current target, set by OSPAR is that less than 10% of the seabirds examined should have more than 0.1g plastic litter in their stomachs. This target has never been reached in any area across the North Sea. For the latest reporting period (2012-2016), 56% of the birds exceeded the 0.1g level, this was a small reduction from the 63% reported from the 2007-2011 period.[123]

Species and habitats

The national indicator for biodiversity (which includes marine species) is assessed as performance maintaining[124,125], however that assessment concerns only the change between the two most recent years and not the longer term. Over the very short-term the index of abundance of (11) marine species rose by 2.7% between 2015 and 2016. However, over the longer-term, between 1994 and 2016 the indicator reveals a sustained decline for marine abundance, with the index falling by 36%.

Scotland's Marine Assessment (2020) found that there was a lack of sufficient data meaning they could not report on trends for some species and habitats. However, they were able to make some conclusions, including:[126]

- There has been a loss in extent for subtidal biogenic habitats (e.g. blue mussel beds, horse mussel beds, serpulid aggregations, cold water coral and maerl beds) in some Scottish Marine Regions (SMRs).
- There have been significant changes to the plankton community over the last 30 years which has potential implications for marine food webs.
- The abundance of harbour porpoise, white-beaked dolphin and minke whale populations in the North Sea has remained stable while coastal bottlenose dolphins have increased in abundance on the east coast and their distribution has expanded.
- the grey seal population has increased, particularly in the east. Meanwhile harbour seal populations are stable on the west coast but in decline in the North and East Coast and Northern Isles.[127] The more recent Scientific Advice on Matters Related to the Management of Seal Populations for

2021[128] supports this assessment although notes that western Scotland harbour populations are increasing in the central and northern sections of the West Scotland Seal Management Unit (SMU) and in the Southwest Scotland SMU.

- Since 2011, overall numbers of seabirds have largely been stable but had a steep decline between 2000 and 2011 with an overall reduction of 38% between 1986 and 2018. Some species show markedly different trends (e.g. decreases in surface-feeding birds).
- The abundance of Scotland's wintering waterbirds continues to increase although, as for seabirds, different species are exhibiting different trends with some species shifting their distribution in response to environmental change.

More information on biodiversity, species and habitats in the marine and freshwater environments is provided in the Biodiversity and Ecosystem Resilience review.

International comparisons

The European Environment Agency State and Outlook report 2020 stated that the Good Environmental Status targets set out in the Marine Directive[129] in relation to contaminants, eutrophication, invasive alien species and marine litter are unlikely to be achieved by 2020[81]. However, it does highlight that some pressures have been reduced and positive outcomes observed although some data gaps remain.

A 2015 report from the European Environment Agency found that, with respect to the Good Environmental Status targets, Europe's seas can be considered productive, but not healthy or clean[130].

Summary

Recent reporting has identified positive improvements in Scotland's marine environment, for example around some levels of contaminants. However a number of issues remain, such as beach litter in some areas and litter ingested by seabirds. There has also been a sustained decline in marine biodiversity over the long term.

A report into progress against the UK Marine Strategy, which Scotland is part of, found that 11 of 15 targets were missed. A similar picture of missed targets is seen in Europe, however the UK appears to have better performance with regards to contaminants and eutrophication.

However, it is important to note that there is limited data to assess the state of the marine environment and so conclusions should be interpreted with caution.

Marine protected areas

Extent of marine protected areas

The Global Aichi Targets (Target 11) set by the Convention on Biological Diversity committed Scotland to have 10% of coastal and marine areas to be designated as protected areas[131]. Scotland has met this target.

There are 245 marine protected area (MPA) sites, meaning 37% of Scotland's seas are protected.[132] Within this, there are 231 MPAs for conservation purposes, one demonstration and research MPA, eight historic MPAs and five Other Area Based Measures recognised as part of the Scottish MPA network.

The development of the MPA network has been progressed between Marine Scotland, Joint Nature Conservation Committee (JNCC[133]), Natural England, Historic Environment Scotland, Scottish Environment Protection Agency (SEPA) and NatureScot, working with a wide range of marine stakeholders.[134]

Effectiveness of marine protected areas

As part of its site condition monitoring (SCM) programme, Nature Scot assess the proportion of protected marine features (within 12 nautical miles, offshore excluded) in favourable condition. As at 31 March 2022, 98.1% of the marine features assessed were in favourable condition[135]. See the biodiversity review for more information.

As part of the MPA designation, a monitoring strategy has been devised for these areas[136]. Monitoring activity will be used to meet the following aims: to determine the condition of the protected features, to identify any changes in the features over time and to assess whether implemented management measures are effective in meeting their objectives.[137] However, there is currently not enough data to assess whether the objectives of the MPA network has been met. There should be enough data by the next publication of Scotland's Marine Assessment.[138]

There have been some reviews of progress in implementing MPA objectives (actions)[139,140]. However, these are outside the scope of the current review.

International comparisons

Networks of protected areas covered 37% of Scotland's sea as at 31 March 2021, compared to 38% for the UK as a whole, 40% for England, 50% for Wales and 35% for Northern Ireland. These percentages mask the fact that Scotland has a much larger sea area to consider. It has actually protected by far the largest area at 22.8 million hectares, compared to 9.3 million hectares for England, 1.5 million hectares for Wales and 0.2 million hectares for Northern Ireland. The total extent of protected areas at sea in the UK has increased in both the short and long-term[141].

The JNCC provides scientific advice to the UK Government and devolved administrations on offshore MPAs[133], and has produced reports evaluating the effectiveness of the system[142] and the condition of specific areas[143]. Its 2016 report[144] concluded that the existing network in England made a significant contribution to the aim of an ecologically coherent MPA network. However, it did identify some shortfalls such as Features of Conservation Interest in all regions.

The European Union committed to the Aichi target to protect 10% of coastal and marine areas by 2020. They reported that by the end of 2016, 10.8% of the surface of Europe's seas had been designated as MPAs, meeting the target[145]. However, the amount of protection varies by geographical location. 27.1 % of the Greater North Sea was covered by MPAs in 2016, the highest proportion of any European regional sea. By contrast, the Aegean-Levantine Sea had only 2.9% MPA coverage, and no new MPAs were designated in this area between 2012 and 2016.

The European Environment Agency suggest that more MPA coverage is required, especially in the Macaronesia region and the Mediterranean Sea as a whole. In addition, they suggest that many sites are good at protecting single vulnerable biodiversity features but may be too small to sustain ecosystem resilience[145]. Furthermore, not all marine features are adequately protected - protected areas cover coastal waters much more comprehensively than offshore waters[146].

Summary

Scotland has met its target for 10% of coastal and marine areas to be designated as protected, 37% of its marine area is protected. There is some evidence to suggest that protected features in marine environments (within 12 nautical miles of the coast) are in favourable condition. However, more data is needed to understand the effectiveness of the protected area system for meeting its objectives.

Scotland has a lower percentage of protected seas than England. However, Scotland has a larger area of protected seas compared to other countries within the UK. Targets for the extent of marine protected areas have also been met in Europe, though with regional variations.

Pressures on the marine and coastal environment

Range of pressures

Scotland's Marine Assessment 2020 identified a range of pressures affecting the marine and coastal environment[116]. Key pressures reported were:

- Climate change – identified as the most critical factor affecting the marine environment with associated impacts including rising sea levels, temperatures and ocean acidification
- Pressures associated with bottom-contacting and pelagic fishing - the most geographically widespread pressure
- Non-indigenous species – pressures increasing
- Underwater noise - however the measurement of extent of the impact is limited

They also highlight that there is a lack of data to fully understand the extent and impact of certain pressures[147].

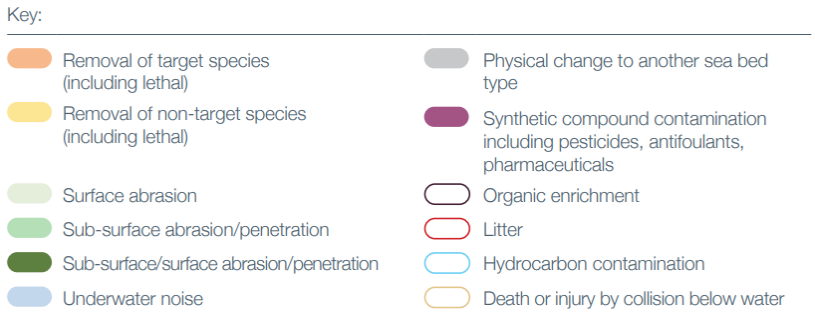
The 2020 assessment also produced figures illustrating the top 5 pressures in Scotland's marine areas, excluding climate change. These are presented in Figure *5* below[147]. In summary, for Scottish Marine Regions, removal of target species was the highest severity pressure in all regions, with removal of non-target species ranking second in seven out of 11 regions. For Offshore Marine Regions, surface abrasion, physical change to another seabed type, sub-surface abrasion/penetration and removal of non-target species emerge as top pressures.

The pressures identified in the 2020 assessment were also identified in previous assessment such as the 2014 State of the Environment report[148] and Scotland's Marine Atlas 2011[118].

Specific anticipated pressures for different marine species have been identified as part of the marine protected area monitoring programme[149].

Scottish Environment Link's recent report suggests that the pressures facing marine life are not yet fully understood but that these ecosystems are fragile and under increasing stress from human activities.[150]

Figure 5: Top 5 Pressures in Scotland's marine areas, excluding climate change



Five main pressures identified per Scottish Marine Region - ranked by severity

Region	Pressures ranked by declining severity from left to right
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	

Five main pressures identified per Offshore Marine Region - ranked by severity

Region	Pressures ranked by declining severity from left to right
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	

* intentionally blank

Source: Scottish Marine Assessment 2020.

Effects of climate change

Scotland's Marine Assessment 2020 identified climate change as the most critical factor affecting the marine environment[116]. They report that the effects of climate change and increasing concentrations of atmospheric greenhouse gas emissions are already being observed in Scotland's marine environment, although the rate and magnitude of these changes are geographically variable[151].

Examples of the impact already observed are:

- Scottish waters (coastal and oceanic) warmed by between 0.05 and 0.07 °C per decade, between 1870 to 2016. However, the warming trend in the last 30 years (1988 to 2017) is about 0.2 °C per decade, while northwards from the region of the Faroe-Shetland Channel trends are reaching 0.4 °C per decade.
- Relative abundance of species and spawning/hatching/migration patterns have changed in different locations with rising temperatures.
- Mean sea level around the coast of Scotland is increasing in all Marine Regions. Stornoway (Outer Hebrides), Kinlochbervie (West Highlands) and Lerwick (Shetland Isles) had the largest changes in the last 30 years.
- Declining oxygen concentrations and high salinity have also been identified. More data is needed on ocean acidification to identify trends.

These trends are likely to continue. In addition, national assessments predict that coastal erosion and coastal flooding will be more significant issues in the future due to sea-level rise and wave-climate changes.

The Climate Change Committee's 2021 climate risk assessment also identifies that marine species and habitats are at risk from climate change[152]. Specifically, they highlight that more action is needed to combat the following risks:

- Changing climatic conditions, including ocean acidification and higher water temperatures which may influence the distribution and abundance of species. For example they may lead to a decline in Atlantic salmon. They may also be influencing the extent of priority seabed habitats
- Pests, pathogens, and invasive species. For example, increasing impacts from viruses, fungi and bacteria have been identified, antimicrobial resistance may also increase in aquaculture due to increased virulence of pathogens at

higher temperatures and expansion of pacific oysters into Scotland due to higher temperatures may threaten native oysters.

- Coastal flooding, erosion, and climate factors

Disturbance to seafloor habitats

The 2020 Marine Assessment concluded that pressures associated with bottom-contacting and pelagic fishing were the most geographically widespread pressure on the marine environment[147].

The predicted disturbance to seafloor habitats indicator from the Environment Strategy monitoring framework[121] reports the predicted extent of physical damage to seafloor habitats due to towed bottom-contact fishing activities in different areas, based on fishing activity and modelling. This includes information about the sensitivity of habitats.

Seafloor habitats are key components of marine ecosystems and play an important role in storing carbon. Seafloor habitats are predicted to be in poor condition across more than half of their area in nine out of twenty one regions, and some level of damage is likely in all regions.

Five (of eleven) Scottish Marine Regions (SMR) and four (of ten) Offshore Marine Regions (OMR) five (of eleven) have more than half of the seafloor with high levels of disturbance.[121] This suggests that disturbance to seafloor habitats is a significant pressure on the marine environment[153].

Pollution discharges

JNCC report data on marine pollution at a UK level. This data suggests that there have been long-term decreases in inputs of hazardous materials into the marine environment. The combined inputs of six hazardous materials (mercury, cadmium, lead, copper, zinc and lindane) has decreased by 78% since 1990[154].

Scotland's Marine Assessment[44] shows 826 outfalls from wastewater treatment (public and private) sources, 214 outfalls from industrial activities (small) and 76 outfalls from industrial activities (large) affected the marine environment in 2018.

The 2020 Marine Assessment reports that there were more outfalls reported in 2018 than 2011 from wastewater treatment and industrial sites due to improvements in data reporting, rather than an actual increase in the number of outfalls. It states that all outfalls are 'subject to strict environmental control and the volumes discharged

are small compared with the receiving sea area'[44]. Further analysis would be needed to fully understand the data and trends.

Aquaculture

Aquaculture is the farming or culturing of fish, molluscs, crustaceans and seaweed and provides Scotland's most valuable food export[155].

Atlantic salmon farming dominates the aquaculture industry in Scotland, responsible for 97% of the total marine aquaculture value[156]. There are thought to be a variety of pressures from aquaculture on the marine environment such as creating barriers to species movement, underwater noise, genetic modification and translocation of indigenous species and removal of species[156],[157].

Pollution discharges are another pressure that can occur from fish farming. Media reports in April 2022 have highlighted that pollution caused by salmon farming rose by 10% (an increase of 4,000 tonnes of discharges of carbon, nitrogen, phosphorus, and zinc from salmon cages) between 2019 and 2020 based on data from SEPA's Scottish Pollutant Release Inventory published in April 2022 and analysed by The Ferret.[158,159] A check of the latest SPRI data suggests that this has decreased to 2021 although is still higher than 2019 levels.

This pollutants increase between 2019 and 2020 was in contrast to the 5.8% decrease in production over the same period recorded by the annual fish farm production survey[160]. Media reports quote SEPA's explanation of the difference that 'due to the pandemic and Brexit, some salmon farm operators had to hold fish on sites for longer than usual, delaying slaughter and reducing production. During this holding time, the fish would still have required feeding, which resulted in increases in emissions directly related to feed.'[158,159]

A report commissioned by Salmon Scotland found that levels of hydrogen peroxide in salmon cages could be 28 times higher than those considered safe for swimmers. However, SEPA and Salmon Scotland have said that it was highly unlikely that swimmers would actually be exposed to such levels.[161]

The Aquaculture Growth to 2030 strategy outlines a vision for the contribution of the aquaculture industry to the Scottish economy to double by 2030[162,163]. However, Scotland's Marine Assessment 2020 recognises that there will be challenges in achieving this growth and balancing pressures on the environment[156].

International comparisons

The European Environment Agency reported in 2018 that the main pressures affecting European seas result from[164]:

- Fishing
- Sea floor damage
- Pollution by nutrient enrichment and contaminants
- The spread of non-indigenous species
- Marine litter and underwater noise - also of growing concern

The 2015 State of Europe's Seas report presents similar pressures[130]:

- Physical damage to the seafloor
- Extraction of fish and shellfish
- Introduction of non-indigenous species
- Input of nutrients leading to eutrophication
- Marine litter

It also highlighted that the combined, cumulative effect of all these pressures on marine ecosystems is an increasingly complex problem to manage.

Similar findings are reported in the 2020 European State and Outlook report, which emphasised that not all pressures are being addressed adequately or fast enough, and that knowledge on the cumulative effects of pressures is lacking[81].

Summary

The main consistently identified pressures on the marine environment are those related to climate change (e.g. rising temperatures, rising sea levels, salinity changes) and fishing activity (e.g. habitat damage, seafloor disturbance, pollution). Removal of species is also a significant pressure. The aquaculture industry also impacts the marine environment (e.g. through barriers to species movement, removal of species and pollution discharges). The planned growth of this industry will need to be balanced with the impacts on the environment. These pressures are relatively widespread and similar pressures have been identified in European seas.

However, the data gaps mean firm conclusions cannot currently be made about the extent and impact of these pressures.

4. Summary of next steps

This baseline review identified a wide range of possible issues for further analysis, including progress against RBMP targets, the extent of water scarcity risk, pressures on the marine environment, the effectiveness of marine protected areas and the extent of the impact of sewage discharge into water on the environment.

However, for the purposes of setting out initial analytical priorities, ESS will focus on:

- Sewage discharge into the aquatic environment;
- Developing a better understanding of threats to the marine environment;
- Understanding water quality issues, with an initial focus on progress against River Basin Management Plan objectives.

ESS' proposed Strategic Plan describes how issues will be prioritised for further analysis according to a range of criteria, including:

- Importance – the size and risk of the potential effect on the environment and/or public health; the urgency with which improvement is required;
- Nature and Scope – recent trends in environmental performance; whether the issue of concern appears to be systematic and/or longstanding;
- Neglect – whether there has been action taken on the issue of concern, or further action is planned in the near future; and
- Added-value – the contribution we could make, considering whether other monitoring, oversight or scrutiny bodies are planning to take, or could take, action to address the issue of concern.

The water analytical priorities take account of that scheme and recognise the importance of these issues. For example, the potential impact that threats to the marine environment can have on other aspects of the environment (e.g. biodiversity, flooding), the international importance of the RBMP process and the public's concern around the impact of sewage discharge. They also consider the lack of data on the issues of sewage discharge and pressures on the marine environment, and the missed targets under RBMP. In keeping with the prioritisation process, the contributions of other actors and the added value that ESS can bring to an area will also be considered, in deciding where to focus future work.

Although ESS intends to focus on three issues in the first instance, other issues will be retained on a list for potential future analysis and horizon scanning in line with the stages of monitoring and analysis work set out in the strategic plan.

5. Summary of key sources

The end notes to this review provide details of the references and sources used throughout the document. This section is intended to provide a shorter note of those reports (in future iterations) and data sources which have been identified as likely to be important for an ongoing understanding of the water environment in Scotland.

Protected freshwaters & Freshwater quality/pollution

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Flooding

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ENVIRONMENTAL
Standards Scotland
Ìrean Àrainneachdail na h-Alba

CONTACT

Environmental Standards Scotland
Thistle House
91 Haymarket Terrace
Edinburgh
Scotland
EH12 5HD

E-mail: **enquiries@environmentalstandards.scot**

Telephone: 0808 1964000