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# Scotland's **Marine Assessment 2020**

Headlines and Next Steps





# Scotland's Marine Assessment 2020

## Headlines and Next Steps

Scotland's vision is for clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of nature and people.



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## Ministerial foreword

Scotland has one of the world's richest, most productive and biologically diverse seas, and it is essential that we protect and enhance our marine environment for future generations. As well as being biologically important, our seas and coasts are home to many essential marine industry sectors that support and sustain communities around Scotland.

The publication of this assessment brings together a wide range of data on the marine environment and the activities that take place in our seas. This assessment provides a comprehensive look at our seas, from rare species of plants and animals to the value generated by marine industries as diverse as aquaculture and tourism.

Scotland's Marine Assessment 2020 provides an up-to-date review of the current state of Scotland's seas, updating Scotland's Marine Atlas published in 2011 and delivering on our statutory requirement to prepare an assessment under the Marine (Scotland) Act 2010. The assessment has identified priority areas that we need to address to protect our marine environment, not least how we continue to tackle the climate emergency. We will use the outputs to inform future marine policy, including the development of a Blue Economy Action Plan as well as the forthcoming review of Scotland's National Marine Plan in 2021. The evidence in this assessment will help us plan for future sustainable development and use of our marine area in a way that will protect and enhance the marine environment whilst promoting both established and emerging industries.

We are clearly in a time of significant change and uncertainty, but also of great opportunity. Scotland has long been looked to as a global leader in driving forward environmental protection and in our ambitious climate change and renewable energy targets.

I am determined that will continue and this assessment will provide a crucial building block in developing the evidence-based policies to support that endeavour.

I would finally like to take this opportunity to recognise and acknowledge the commitment and input from a wide range of people throughout the development of this assessment. The completion of this assessment is an excellent example of collaboration, with more than 250 individuals, four statutory organisations and many colleagues from the academic community, under the umbrella of the Marine Alliance for Science and Technology for Scotland, working together over a two year period, on a common goal to deliver this high quality assessment.



A handwritten signature in black ink, appearing to read 'R. Cunningham'.

### **Roseanna Cunningham MSP**

Cabinet Secretary for Environment, Climate Change and Land Reform

## Introduction

Scotland's Marine Assessment 2020 (SMA2020) is the third in a series of reports describing the state of the marine environment produced by the Scottish Government. 'Scotland's Seas: Towards Understanding their State', published in 2008, was followed, in 2011, by 'Scotland's Marine Atlas: Information for the National Marine Plan'.

SMA2020 is another step forward in understanding how marine systems work and the impact that human activities are having. However, in the last ten years the impact of climate change has become increasingly apparent. Furthermore, the concepts of natural capital and ecosystems services are now widely accepted as a way of better understanding the benefits to society from Scotland's seas. Both these topics have been included in greater detail than presented in Scotland's Marine Atlas (2011).

SMA2020 is a statutory requirement, a prerequisite of a review of Scotland's National Marine Plan. An assessment of the key human pressures by marine region is also required. It is the first, bespoke, attempt at such an assessment across all 21 Scottish Marine Regions and Offshore Marine Regions, which themselves have been created since the publication of Scotland's Marine Atlas (2011).

This document summarises the key findings for each topic as well as presenting headlines and next steps. For much of SMA2020 the cut-off date for data was the end of 2018. Where practicable, more recent data have been used. Data published in the last few months have not been incorporated into the assessments.

In 2021, the human pressures on Scotland's seas are significant. The situation is further complicated by climate change. However, Scotland has an extremely able and active

community of natural, economic and social scientists of which more than 250 have contributed to SMA2020.

Scotland is fortunate in being able to rely on the academic community, through the Marine Alliance for Science and Technology for Scotland (MASTS), for unstinting support in delivering this assessment. Scotland also has dedicated teams in Marine Scotland, NatureScot, the Scottish Environment Protection Agency and the Joint Nature Conservation Committee. The contributions from staff belonging to these organisations and MASTS institutes has been immense. I thank every single one of them.

Reports such as SMA2020 require consistent and sustained work over several years. The dedication of those members of Scotland's Seas Data Assessment Group has made my job as chair more straightforward. My deepest gratitude to all involved. I also thank the peer reviewers who have been extremely diligent in their work. Their comments have been most helpful in finalising SMA2020.

The ocean is essential to life on Earth. SMA2020 presents a snapshot of the state of the seas around Scotland. We will continue to work on the major challenges ahead. I hope that SMA2020 will enhance peoples' understanding of what is occurring in the seas around Scotland and encourage progressive processes that will guarantee a balance between utilisation and protection.

**Colin Moffat**  
Chair, SSDAG  
March 2021

## Headlines

**Progress is being made** in improving the state of Scotland's seas especially in relation to contaminants. Eutrophication is not an issue in Scotland's seas. 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, while the ability to draw conclusions about benthic habitats and underwater noise is limited by current knowledge.

**The marine economy (2017)** is worth £14.66 billion Gross Value Added (GVA) to Scotland of which £9.52 billion GVA is oil and gas extraction and £5.14 billion GVA comes from other marine industries. This supports important marine sectors including, energy, food production, transport/communications, sport, leisure and recreation, as well as bringing significant well-being to individuals.

**Many marine industries are of growing importance to the Scottish economy.** Offshore wind (fixed and floating) and marine energy (wave energy and tidal stream) generation increased by 142% between 2014 and 2018 and employment in marine tourism by 16% between 2008 and 2017. The GVA trend for aquaculture, 2013 to 2017, increased by 58% from £224 million to £354 million with employment increasing by 20%.

**Climate change** is the most critical factor affecting Scotland's marine environment. Impacts are already being seen across the Scottish marine ecosystem. For example, mean sea level around the coast is increasing in all Marine Regions, with the largest changes in the last 30 years observed at Stornoway, Kinlochbervie and Lerwick, increasing the risk of assets being damaged from coastal flooding and coastal erosion. Furthermore, the rise in sea temperature is causing changes in species distributions.

**Recent evidence on ocean acidification** shows that it has the potential to have an impact on shellfish and other marine invertebrates in Scotland's seas, one of a number of increasing stressors which, in combination, will potentially have significant consequences for the sectors and communities that depend on them.

**Pressures** associated with bottom-contacting and pelagic fishing continue to be the most geographically widespread, direct pressures across the majority of Scottish Marine Regions and Offshore Marine Regions.

**Measures** are being implemented in response to recognised concerns. Some, such as fisheries management, have been in place for decades, evolving throughout that period to respond to changes in marine ecosystems. Measures will continue to be developed to address current and future challenges, including those highlighted in this assessment.

**Marine Protected Areas** and measures to tackle marine litter, have developed quite recently and need more time to be fully effective. In addition, further measures are required in response to the loss of biodiversity, impacts associated with climate change and ocean acidification, and to continue to support the aim of sustainable use of Scotland's seas.

**There are insufficient data** to allow detailed assessment at the scale of the Scottish Marine Regions and Offshore Marine Regions. There are too few ecosystem monitoring sites and understanding cumulative impacts remains a significant challenge.

**Delivering** clean, healthy, biologically diverse and productive seas will only happen through closer coordination and collaboration, including with coastal communities and international partners.





## Next Steps

### **A. Scotland will continue to develop and improve the body of scientific (natural, social and economic) evidence to inform policy decisions relating to the management of human activities having an impact on Scotland's seas:**

The evidence from SMA2020 and other assessments indicate that the rate of change due to human activities in marine systems is accelerating. These assessments will continue to be available to inform public awareness and government policy.

### **B. Our marine science community will work to improve our collective understanding of our marine environment:**

Many initiatives and strategies exist which provide information and direction. Locally and globally, indicators have been developed, and relevant indicators are used in SMA2020. These provide the basis for informing the action required today. However, further development and refinement of indicators, especially in the healthy and biologically diverse context, is needed to enhance advice and decision-making.

### **C. Future work on Scotland's National Marine Plan will take an ecosystem-based approach to the protection of Scotland's seas in the management of human activities:**

As the environment becomes more unpredictable and unstable, with increasing impacts from climate change, SMA2020 shows that the resilience of ecosystems will change. For example, species that can, will move. Those species dependent on ocean currents for dispersal may be affected. Taking account of such changes, including those that are human induced, when considering, developing and implementing marine management measures will be integral to our statutory review of the National Marine Plan in the coming months.

### **D. The national dialogue must be diverse and effective:**

The changes that are occurring are accelerating and will have societal impacts, especially on coastal communities and marine sectors. There is a strong imperative to continue to work hard on communicating the state

of Scotland's seas with a range of different audiences, allowing decisions to be reached collaboratively about the measures required to address the impacts of human activities.

### **E. SMA2020 highlights the challenges for the Scottish marine science community to:**

#### **(1) Improve the predictions of climate change impacts:**

Climate change is already resulting in changes in the seas around Scotland, and the pace of change is predicted to increase between now and the next assessment. The most significant changes for Scotland over the next 10 to 20 years still need to be identified and measures will be required to help mitigate and adapt to these changes.

**(2) Assess cumulative pressures:** While the understanding of the impact of individual pressures (cause and effect) has merit, the reality is that Scotland's seas are subject to multiple pressures, including those arising from a rapidly changing climate. Methods need to be developed that enable future scientific advice to take account of multiple pressures and cumulative impacts.

#### **(3) Improve the understanding of natural capital and ecosystem services:**

The assessment of economic and social value continues to improve. However, in line with the recommendations last year from the Advisory Group on Economic Recovery there is a need to work collaboratively to embed the concepts of ecosystem services and natural capital in respect of the seas around Scotland. This should be set within the broader context of improved integration of social and natural sciences.

#### **(4) Ensure that account is taken of the bigger marine environmental picture:**

The movement of pollutants by the currents in the seas and winds in the atmosphere means that the state of the seas around Scotland is not just affected by activities and actions taken in Scotland, and vice versa. A continued involvement and leadership in international initiatives will ensure a joined-up approach across national borders.



**(5) Improve the availability of data:** The preparation of SMA2020 has involved many experts using the available data. However, some gaps in knowledge exist and not all data are widely available. Enhanced efforts will be made to capture all data relevant to a specific assessment, thereby delivering the most comprehensive evidence-base to guide decision-making, following the 'collect once, use many times' principle, accepting that there will always be gaps in knowledge.

**(6) Undertake sustained monitoring and investigative research to explain change:**

The natural variability in marine systems is large. This means there is a need to explore in greater capacity within Scotland when and where change is occurring and the cause of the change.

**(7) Maximise the benefit of our scientific monitoring:** Monitoring programmes relevant to the seas around Scotland will be reviewed to make sure that, collectively, they provide the necessary data at the required scale to support future assessments. Challenges include responding to emerging topics and adopting more cost-effective ways to obtain data using new technologies.

## Scotland's Marine Assessment 2020 portal

The SMA2020 portal provides the detail of the assessments and a range of case studies that are summarised in the *Headlines and Next Steps*.

The SMA2020 portal, [Marine Scotland Assessment](#), is part of the Marine Scotland Open Data Network (MSODN) which also includes [Marine Scotland Information](#), [Marine Scotland Maps](#) NMPi and [Marine Scotland Data](#). SMA2020 is supported with the MSODN providing links to spatial data layers and appropriate assessment metadata. SMA2020 has been designed to be intuitive and flexible to use on the wide range of platforms available. Sections take their names from the elements of the vision for Scotland's seas being reported e.g. Clean and safe, etc. In addition, there are Topics, for example, Introduction and Climate change, that contain the following material:

### Introduction



### Managing the human activities that have an impact on Scotland's seas



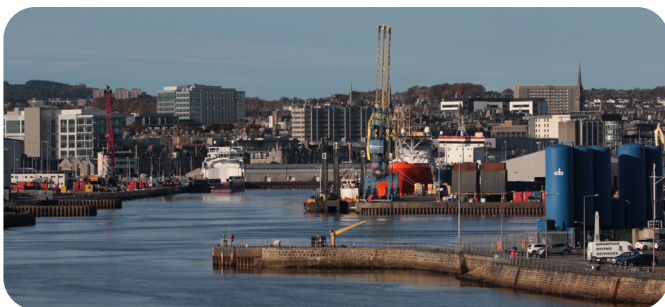
#### Climate change

Assessments of 'What is already happening?' and 'What is likely to happen in future?'



#### Natural capital, ecosystem services and the blue economy

Assessments of the natural benefits from Scotland's seas.



#### Pressures from activities

Results from the MASTS-led expert workshop with an assessment for each Scottish Marine Region (SMR) and Offshore Marine Region (OMR).



#### Regional assessments

Based on the various assessments, a summary for each SMR and OMR.

## Assessments related to the vision for Scotland's seas

A standard structure is used for the assessments related to the vision:

| Clean and safe<br>Healthy and biologically diverse<br>Physical characteristics | Productive                         |
|--|------------------------------------|
| Key message  | Key message                        |
| Background   | What, why and where?               |
| Assessment methods   | Contribution to the economy        |
| Results  | Examples of socio-economic effects |
| Conclusion   | Pressures on the environment       |
| Knowledge gaps   | Forward look                       |
| Status and trend assessment  | Economic trend assessment          |
| Links and resources  | Links and resources                |

## Pressures from activities

Key to SMA2020 is the summary of significant pressures that are a requirement under the Marine (Scotland) Act 2010. The image below shows an example of the priority pressures table for the Solway SMR, which provides links to other parts of the SMA2020.

| [1] Priority | [2] Pressure (FeAST)                             | [3] Main ecosystem components affected   | [4] Main contributing FeAST activity /activities to pressure   | Productive assessments  |
|--------------|--|--|--|---|
| 1            | Removal of target species (including lethal)     | <ul style="list-style-type: none"> <li>Commercial fish</li> <li>Commercial shellfish</li> </ul>  | <ul style="list-style-type: none"> <li>Bottom otter trawling and pair trawls (OTB, OTT, PTB, TB, TBN)</li> <li>Creeling and potting (FPO)</li> <li>Dive fishoria (not including hydraulic dredging) (HF, MIS)</li> <li>Lino fishing (hand and mechanized lino and longlining) (LHP, LHM, LL, LLS)</li> <li>Recreational Fishing</li> <li>Scallop dredging (DRB)</li> </ul> | <ul style="list-style-type: none"> <li>Fishing</li> </ul>   |
| 2            | Surface abrasion                                 | <ul style="list-style-type: none"> <li>Marine Protected Areas</li> <li>Extent of physical damage to seafloor habitats</li> </ul>   | <ul style="list-style-type: none"> <li>Bottom otter trawling and pair trawls (OTB, OTT, PTB, TB, TBN)</li> <li>Creeling and potting (FPO)</li> <li>Scallop dredging (DRB)</li> </ul>   | <ul style="list-style-type: none"> <li>Fishing</li> </ul>   |
| 3            | Removal of non-target species (including lethal) | <ul style="list-style-type: none"> <li>Seals</li> <li>Cetaceans</li> <li>Commercial fish</li> <li>Commercial shellfish</li> <li>Wider fish community</li> <li>Inshore fish (estuaries and reduced salinity sea lochs)</li> </ul> | <ul style="list-style-type: none"> <li>Aquaculture Finfish</li> <li>Bottom otter trawling and pair trawls (OTB, OTT, PTB, TB, TBN)</li> <li>Creeling and potting (FPO)</li> <li>Intertidal fishing (e.g. bait digging but not bylines)</li> <li>Lino fishing (hand and mechanized line and longlining) (LHP, LHM, LL, LLS)</li> </ul>                                      | <ul style="list-style-type: none"> <li>Aquaculture</li> <li>Fishing</li> </ul>  |
| 4            | Underwater noise                                 | <ul style="list-style-type: none"> <li>Seals</li> <li>Cetaceans</li> <li>Commercial fish</li> <li>Salmon and sea trout</li> <li>Wider fish community</li> </ul>  | <ul style="list-style-type: none"> <li>Aquaculture Finfish</li> <li>Military activities – sea surface activity</li> <li>Military activities – sonar use</li> <li>Shipping</li> <li>Tourism &amp; recreation</li> </ul>   | <ul style="list-style-type: none"> <li>Leisure and recreation</li> <li>Defence (Military)</li> <li>Aquaculture</li> </ul> |

## Printable summaries



Downloadable summary pdfs are available for each of the Physical characteristics and ocean acidification, Clean and safe, Healthy and biologically diverse and Productive assessments.

**PHYSICAL CHARACTERISTICS AND OCEAN ACIDIFICATION**  
Temperature

**Key message**  
Temperatures have increased in all regions, with an increased rate of change over the 1981-2010 climatological period and no significant linear trend in the most recent decade. These changes are due to both the long-term global increase in temperature and the regional variations of this trend in the Atlantic Ocean. The shallow North Sea has warmed faster than regions to the north and west.

**Background**  
Sea surface temperatures (SST) around Scotland are strongly influenced by the atmosphere (heat flux) and ocean circulation (advection). When looking at trends around Scotland over long periods of time (more than 50 years) SSTs show an increasing trend in line with global trends, as the entire Earth system has been absorbing more heat with climate change. On decadal and shorter time periods, these trends can differ, and can even be less obvious (and not statistically significant) due to variability on shorter time scales. The conditions in the adjacent North Atlantic Ocean influence regional temperatures in Scotland via both atmospheric and advective processes. Temperature variability in Scottish waters is provided regularly as part of the Scottish Ocean Climate Status Report (Hughes et al., 2018). For brevity, this assessment focuses on sea surface temperature (SST) in Scottish waters. The average sea surface temperature across each Scottish Marine Region (SMR) demonstrates the influence of the adjacent North Atlantic Ocean with winter SST on the west coast of Scotland tending to remain higher than those in the north and east of Scotland. The average winter SST in the Angul region (to the west) is almost 1.5 °C greater than average winter temperature in the North East region (Hughes et al., 2018). SSTs around Scotland follow a seasonal cycle, similar to that in air temperature, but peak temperatures in the sea are approximately a month later, in August.

**Results**  
The regional temperatures in the sub-polar North Atlantic during the 1981 - 2010 climatological period were increasing, faster than 1993 - 2018 trends, due to changes in Atlantic Ocean circulation outside Scottish waters, due to the strong influence of the North Atlantic on conditions in Scottish waters. The trends in this region during the 1981 - 2010 period are also higher than the 1993 - 2018 trend. Since 2016, the circulation of the North Atlantic sub-polar gyre has changed, which means the properties of Atlantic water have become cooler and fresher. Therefore, there has been no significant trend in the most recent decade.

For further information on this topic go to: <https://marine.gov.scot/sma/assessment/temperature>

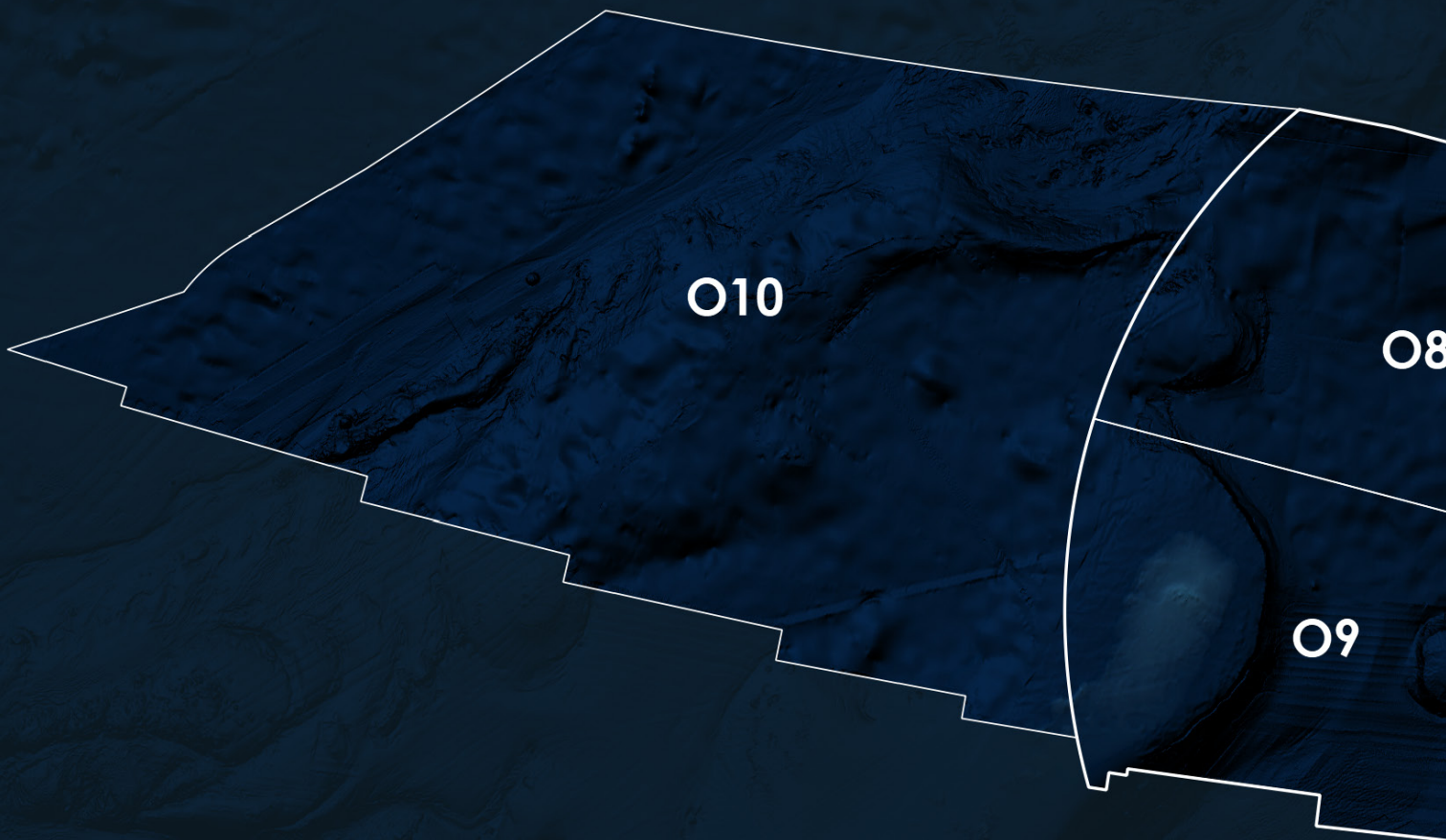
## Key

### Scottish Marine Regions

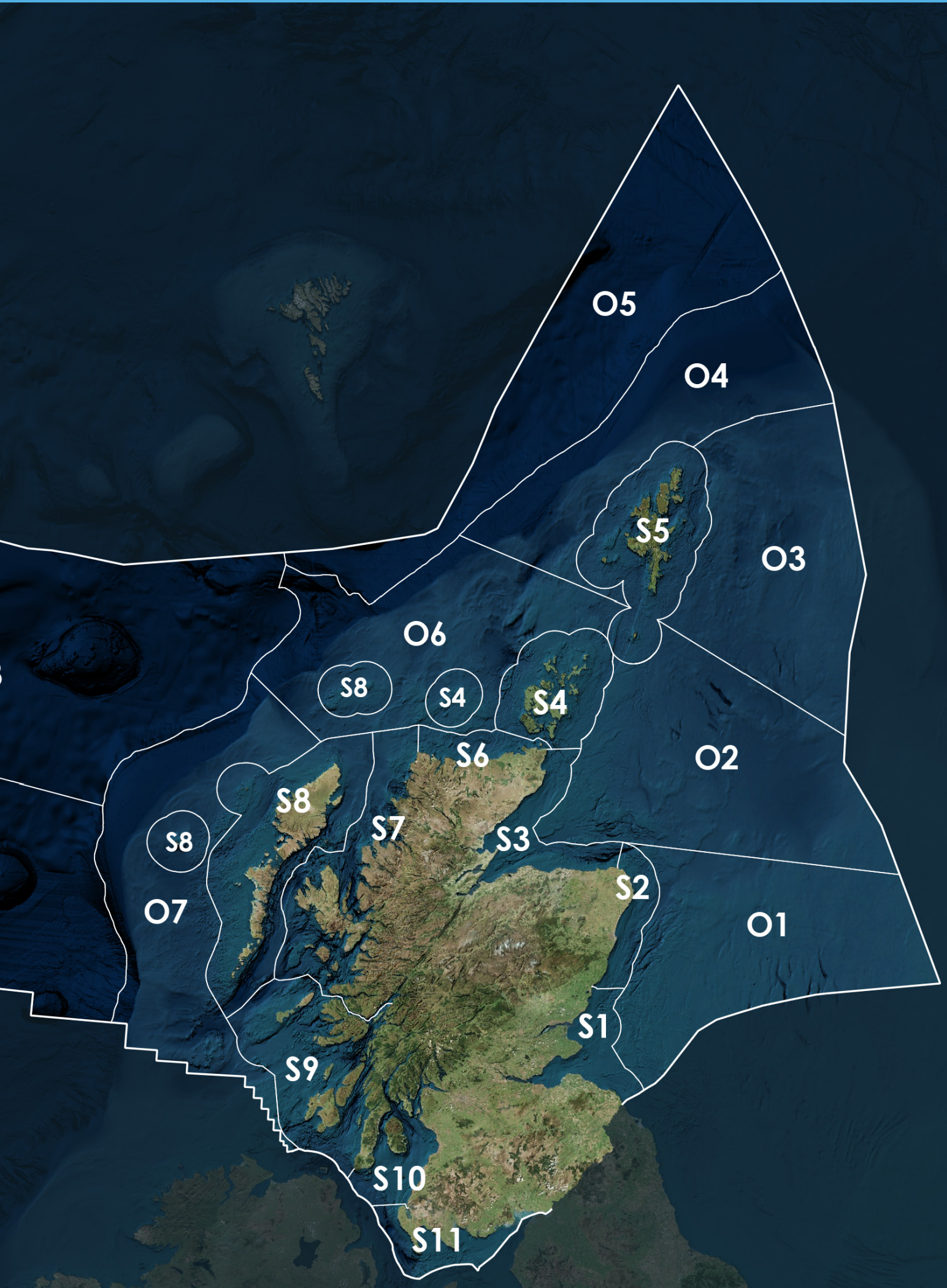
- S1** Forth and Tay
- S2** North East
- S3** Moray Firth
- S4** Orkney Islands
- S5** Shetland Isles
- S6** North Coast
- S7** West Highlands
- S8** Outer Hebrides
- S9** Argyll
- S10** Clyde
- S11** Solway

### Offshore Marine Regions

- 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



For the purpose of SMA2020, and future assessments, SMRs and OMRs are used. The SMRs are defined in The Scottish Marine Regions Order 2015. The OMRs were developed by Marine Scotland. Where practicable, the 21 SMRs and OMRs have been used as the geographic assessment units. Where this has not been possible, or is not appropriate, details of the areas used have been provided.



# Climate change



# 19

## Assessments

More information on the regions used in the Climate change assessment is available on the Assessment processes and methods page of the SMA2020 portal: <http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

## Key words

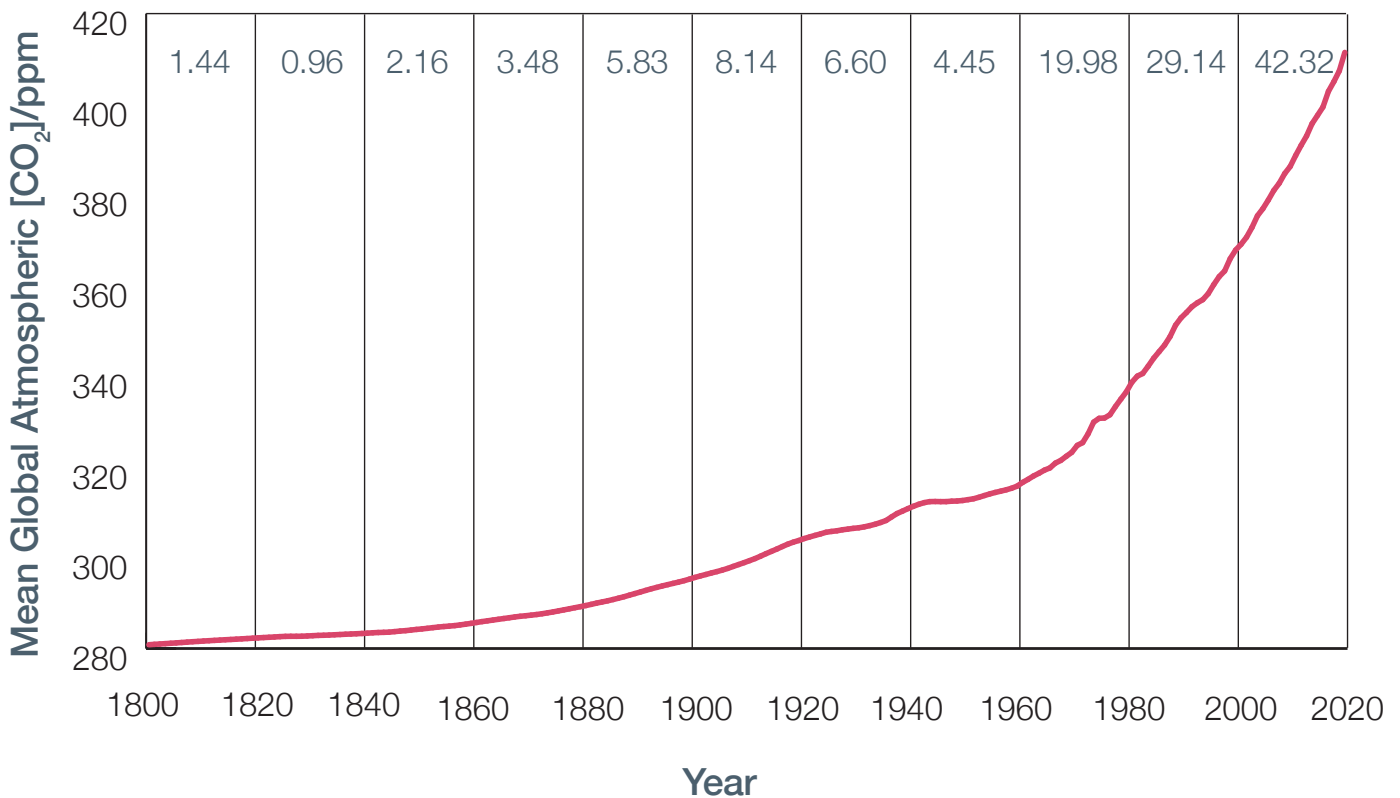
**greenhouse gases**  
**carbon dioxide**  
**decreasing pH**  
**acidification** **temperature**  
**circulation patterns** **salinity**  
**sea-level rise** **deoxygenation**  
**ocean currents** **mitigation**  
**stratification** **blue carbon**  
**species distributions**  
**adaptation** **climate**  
**blue economy**



## What is covered

Emissions of greenhouse gases, including carbon dioxide (CO<sub>2</sub>) and methane (CH<sub>4</sub>) continue to increase. The consequence of this is that changes in the ocean are occurring. The ocean has absorbed about 89% of the excess heat in the Earth's climate system resulting from the human activities that produce greenhouse gases, and between 20-30% of the additional carbon dioxide since the mid-1980s. This has led to an increase in water temperature, a reduction in dissolved oxygen and a decrease in pH globally. Sea-level rise, due to both the thermal

expansion of water and the input of fresh water from the melting of glaciers and the ice sheets, will have an impact on coastal communities and infrastructure. These changes also have an impact on marine species and habitats. Adaptation to climate change and a reduction of greenhouse gas emissions can be supported by the use of the marine environment, for example through offshore wind and renewable energy. However, some future changes are already locked in due to the residence time of these greenhouse gases in the atmosphere.



Mean global atmospheric carbon dioxide concentration (ppm dry air) over the period 1800–2019 inclusive. The numbers along the top (units: ppm) are the difference over the 20 year period indicated by the vertical lines. ([Dataset downloaded from the Institute for Atmospheric and Climate Science, Zurich, Switzerland 27 Oct 2020](#) other than the 2019 point which is the annual average at Mauna Loa, Hawaii which was used as the global mean was not available).

## The basis of the assessment

This climate assessment uses the recent (last 10 years, but particularly the last 3 years) scientific literature, including several key reports and documents which have been published by the scientific community in the last two years. These are:

- **The IPCC Special Report on Global Warming of 1.5°C (SR1.5)**  
<https://www.ipcc.ch/sr15/>
- **The IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)**  
<https://www.ipcc.ch/srocc/home/>
- **The Marine Climate Change Impacts Report Card 2020 and backing papers produced by the UK Marine Climate Change Impacts Partnership (MCCIP)**  
<http://www.mccip.org.uk/impacts-report-cards/full-report-cards/2020/>
- **The Scottish Ocean Climate Status Report 2016 prepared by Marine Scotland Science**  
<https://data.marine.gov.scot/dataset/scottish-ocean-climate-status-report-2016>

## Summary of key messages

Effects on Scotland's seas of the increase in concentrations of atmospheric greenhouse gases (GHGs) are being observed. The rate and magnitude of these changes are geographically variable. While the atmospheric concentrations of GHGs continue to rise, additional and greater effects will be observed. However, the longer-term future will depend on the rate and direction of change in the concentration of atmospheric GHGs.

The key messages are summarised on the basis of:

- Physical changes.
- Coastal consequences.
- Fish and fisheries.
- Species and habitats.
- Impacts on the Blue Economy.
- Supporting the transition to net zero.



“ The impacts of climate change have already been observed in Scotland's seas with evidence of warming seas and increasing sea levels, for example. These changes are increasingly having an impact on the marine ecosystem. ”

Bee Berx, Topic lead

## Physical changes

Scottish waters (coastal and oceanic) have warmed by between 0.05 and 0.07 °C per decade, calculated across the period 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.

Mean sea level around the coast of Scotland is increasing in all Marine Regions, with the largest changes in the last 30 years observed at Stornoway (Outer Hebrides SMR), Kinlochbervie (West Highlands SMR) and Lerwick (Shetland Isles SMR).

There has been a decline in the oxygen concentration in the water since 1990 in the stratified regions of the North Sea due to both a decrease in solubility resulting from warming and due to an increase in oxygen utilisation from changes in metabolic rates and community structure. Oxygen depletion and ocean warming together will, in the future, result in changes in the viable habitat for a number of species, including commercially important ones such as marine fish.

## Coastal consequences

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. Coastal habitats are also experiencing the effects of increased temperatures. The effects of these will be particularly profound for the exposed, low-lying dune-wetland habitat complexes such as those found in the Outer Hebrides.

At Stonehaven, the seasonal range in pH can be as high as 0.3 pH units, however, currently there is not a dataset for Scottish waters that allows any trend in acidification to be detected.

In the last 20 years there has been a period of sustained high salinity in the offshore water masses. In areas with significant river inputs (Clyde, Forth, Inverness, Beaulieu, Cromarty and Dornoch Firths), stratification due to river run-off (input of fresh water) can occur year-round. There is currently no evidence that the strength of stratification in these regions is systematically changing.

Currently, there is no evidence that the ocean currents in Scottish waters are significantly changing due to climate change. However, the Atlantic Meridional Overturning Circulation (AMOC) will very likely slow down by the end of the century which will result in less heat conveyed northwards in the atmosphere and ocean around Scotland.

Any shoreline management planning and coastal adaptation strategies will have to take account of transformative change to some semi-natural shorelines, significant maintenance challenges for existing built defences, and a longer-term need to consider relocating certain assets that are at risk.

## Fish and fisheries

Communities of bottom-living fishes have shifted towards a dominance by warm-water species (e.g. lesser-spotted dogfish, hake, horse mackerel) and away from cold-water ones (e.g. Atlantic cod, Atlantic herring, sprat) as the sea water has warmed.

The biggest declines in occurrence of species in trawl surveys in waters off North-east Scotland have been in cold-water Atlantic cod and Atlantic herring.

Distributional shifts in species have been mainly linked to temperature changes but may also be partly due to changes in prey distribution.

Species richness on the west coast of Scotland has increased due to a rise in temperature.

Evidence from different fish species suggests climate change is having an impact on the timing of spawning, hatching and migration. For example, in Scottish waters the earlier development of Atlantic cod reproductive organs (gonads) and the delay of those in sandeel have been observed.

A temperature-related reduction in adult maximum body size in six commercial fish species (haddock, whiting, herring, Norway pout, plaice and sole) has been detected in the North Sea. This is due to temperature-related changes in oxygen demand and the metabolic cost of activities such as movement, reproduction and eating.

Whiting could increase in abundance as a result of rising temperatures and declines in predators such as Atlantic cod, but may also be compromised by changes in plankton and by ocean acidification.

## Species and habitats

Oxygen depletion and ocean warming together will in the future result in changes in the viable habitat for a number of species.

Non-native species are appearing on Scotland's coasts, with many of these being warm-water species.

Models predict large-scale spatial declines in distribution of maerl beds under all [IPCC Representative Concentration Pathways](#), ranging from 38% decline under the "low emission scenario" up to 84% decline under the "high emission scenario", with the most rapid rate of decline occurring up to 2050.

The apparent range shifts observed for some cetaceans around Scotland may reflect changing distributions of particular fish prey species in response to climate change.

Sea-level rise may affect current seal haul-out sites around Scotland, with some critical habitat, such as the Monach Isles (home to the largest grey seal colony in the eastern Atlantic) disappearing under water in future. However, it is unlikely this will happen at a rate that would prevent an adaptive shift in distribution to new haul-out sites.

There have been significant changes in plankton life forms in the last 30 years within the entire North Sea and North Atlantic Ocean. Climate change is one of multiple factors influencing long-term trends in plankton abundance in Scottish waters.

The possible long-term consequences of climate change on seabirds are not yet fully understood.

## Impacts on the Blue Economy

Currently, no clear impacts due to climate change have been established for aquaculture of finfish or shellfish. This industry will face a number of challenges in the future likely to include an increased occurrence of pathogens and parasites, while the shellfish sector will likely experience impacts from ocean acidification.

Marine transport and coastal infrastructure, important parts of Scotland's coastal economy, are likely to experience the impacts of changes to extreme weather events (such as storms) and sea-level rise.

## Summary of knowledge gaps

While the understanding of climate change has significantly improved since the last assessment, many unknowns remain. The following knowledge gaps have been identified:

- 1.** Understanding of mechanisms and processes linking the changes observed in the physical environment to individual organisms, their populations and the marine foodweb to ensure confident prediction of future change.
- 2.** Distinguishing the long-term anthropogenic signal from the natural variability, especially of coastal systems.
- 3.** The combined impact on species of climate stressors (deoxygenation, increasing temperature, increase in acidity) with loss of habitat, presence of contaminants and a change in pathogens.
- 4.** The consequences of climate feedback mechanisms and their contribution to the rate of change in the physical characteristics of marine ecosystems.
- 5.** The consequences of marine systems passing critical tipping points which may not be readily reversed. There is also lack of understanding as to the nature of these tipping points.
- 6.** Being able to identify changes in marine ecosystems as a direct consequence of mitigating actions and the timescales over which such changes are expected to occur.

## Supporting the transition to net zero

Marine renewable energy developments (including offshore wind and tidal in the future) will help to reduce greenhouse gas emissions.

Carbon Capture Utilisation and Storage (CCUS) will be needed to ensure the net zero legislation targets are met by 2045. The theoretical carbon dioxide storage capacity of the continental shelf adjacent to Scotland is 46 Gigatonnes.

Sedimentary carbon stores across the continental shelf are significant, with the Scottish sea lochs in particular providing hotspots of carbon burial. Other habitats with significant carbon stores are maerl beds, saltmarsh, seagrass beds and various biogenic habitats. Protection of these habitats and their stores will be critical.

# Physical characteristics and ocean acidification



**8**  
Assessments

**4**  
Case studies

More information on the regions used in the Physical characteristics and ocean acidification assessment is available on the Assessment processes and methods page of the SMA2020 portal: <http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

## Key words

sea level  
tides turbidity  
prevailing conditions  
ocean acidification  
wave-climate  
ocean circulation  
temperature  
ocean climate  
stratification salinity  
sustained ocean observations

## What is covered

The physical characteristics of the marine environment are important for the fauna and flora living in the sea. Productivity of the marine ecosystem is in part governed by the ocean climate. These assessments provide information on:

- The temperature and salinity of Scotland's seas.
- The ocean circulation, tides, sea level and wave-climate.
- The stratification of the water column.
- Ocean acidification.

## The basis of the assessment

The assessments of these physical characteristics are based on trend analyses in each of the SMRs and OMRs, using a range of observational data and computer model outputs from Scottish and international monitoring programmes.



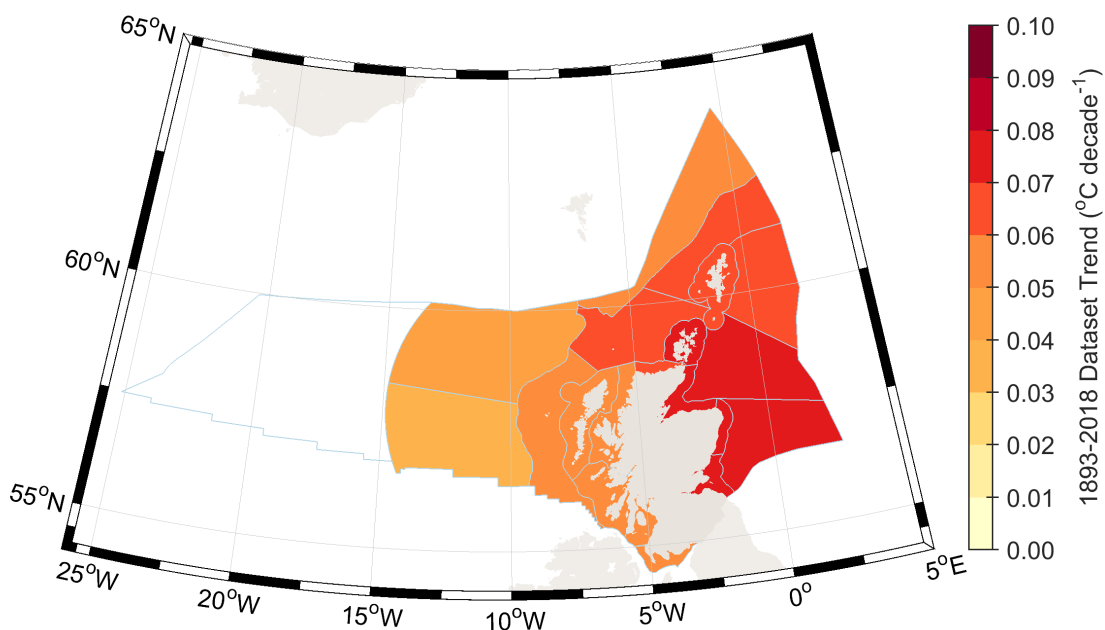
## Summary of key messages

Sea surface temperatures have increased in all regions over the last 100 years. In the most recent decade, year-to-year variability has been high, and no significant trend has been seen. Salinities have recently decreased due to a freshening of source waters in the north Atlantic Ocean. These changes have also been observed in the coastal regions, although year-to-year variability is higher here due to the influence of freshwater run-off.

Sea level around the Scottish coast is rising due to global warming, although the rate of increase differs across regions. The wave climate in the most recent five years has been close to the long-term average conditions. The assessments of ocean circulation and stratification provide an overview of prevailing conditions as there is insufficient evidence to support trend assessments.

The Scottish ocean acidification dataset consists of five years of measurements, which is insufficient to calculate accurate trends in ocean acidification. The data are consistent with both UK and global data for coastal/shelf sea areas with the carbonate system having a strong seasonal cycle linked to biological activity.

- Sea surface temperatures are increasing over long time scales due to global climate change. Year-to-year variability has been high in recent years, masking this underlying trend.
- Salinity has been below average in recent years due to a reduction in salinity (freshening) of source waters in the Atlantic Ocean.
- New observational programmes to measure important parameters such as ocean acidification are being established.
- For some assessments, there are limited data or an absence of assessment criteria which prevents a full status assessment being undertaken, especially at the scale of an SMR.



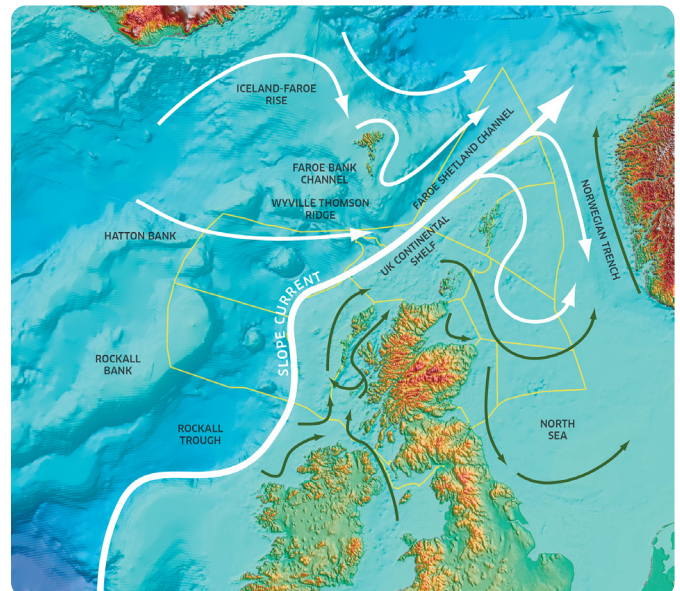
SST trend from the HadISST 1.1 data product for the entire observational period (1893 - 2018) averaged by SMR and OMR. Note the colour scale ranges from 0 to 0.10 °C per decade. The trend in the Hatton OMR is statistically not significant, and has therefore not been included.



## Summary of knowledge gaps

The signals of global warming due to anthropogenic greenhouse gas emissions are evident in some of the physical characteristics of Scotland's marine environment. However, to improve the understanding will require continued investment in ocean observing programmes. Emerging technologies, satellite observations and computer simulations could help address some of the gaps in the monitoring network. The following knowledge gaps have been identified:

1. Sustained ocean observations to collect data of essential ocean variables, such as ocean temperature, salinity, currents, turbidity, ocean acidification, dissolved oxygen, stratification and waves.
2. A lack of spatial extent, resolution and frequency in the data obtained from observational programmes that rely on *in situ* sampling.
3. The dynamics governing year-to-year variability and the links to the marine ecosystem, particularly for parameters such as ocean acidification, stratification, turbidity, waves and ocean currents.



“ Knowledge of changes in the physical and chemical environment of Scotland's seas is important to provide context to changes seen across the ecosystem.”

Bee Berx, Topic lead



# Clean and safe

More information on the regions used in the Clean and safe assessment is available on the Assessment processes and methods page of the SMA2020 portal: <http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

## Key words

23

Assessments

8

Case Studies

nutrients  
bathing water  
PAH  
viruses  
organic  
PBDE  
hot spots  
phycotoxins  
marine litter  
eutrophication  
radionuclides  
impulsive noise  
continuous noise  
BAC deoxygenation  
metals microplastics  
chemical discharges  
disease contaminants  
EAC PCB biological effects  
imposex bacteria

## What is covered

The marine environment is a sink for many hazardous substances, nutrients and litter. To establish the state of Scotland's seas, and how 'clean and safe' the seas are, consideration has been given to:

- The concentration and effects of heavy metals and organic contaminants in biota and sediments.
- The direct and indirect effects of nutrient enrichment.
- The dose of radiation to which individuals may be exposed from the authorised disposal of radioactive waste.
- Oil and chemical discharges and releases.
- The impact of microplastics, seafloor litter and beach litter, microbial contamination in shellfish, phycotoxin concentrations in harvested bivalves and the associated occurrence of toxin-producing phytoplankton in shellfish production areas.
- The consequences of continuous or impulsive noise on marine animals.

## The basis of the assessment

The assessment both of hazardous substances and the effects of nutrient enrichment are based on well-established, internationally-recognised, long-term programmes that use agreed assessment values and thresholds.

The assessment of the microbial and toxin contamination of shellfish is based on a significant time series of data. The assessment of beach litter includes OSPAR reference beaches that are surveyed four times per year using an internationally-agreed standard method. This contrasts with both microplastics in the sea and noise, which are more recent issues of concern. For example, the continuous noise assessment, reported for the first time in 2020, used ten underwater recording stations, monitored in 2013 and 2014, to provide baseline data. The impulsive noise assessment is based on Marine Noise Registry returns from 2015-2017 while the assessment of microplastics in sea surface waters (top 10 cm) is the first using the data collected over the period 2014-2019.



## Summary of key messages

Improvements in the condition of the seas around Scotland are being observed. However, it is important to note that for some regions there are many local concerns. For example, although the Irish Sea biogeographic assessment region is classified as having few or no concerns as a whole with respect to contaminant concentrations, it is noted that many local concerns, particularly in the Firth of Clyde, exist. Some sites exceed the assessment value above which biological effects are expected. A further issue is data availability. Confidence in the eutrophication assessment (both status and trend) is limited by a lack of data on dissolved oxygen. Due to the variable temporal and geographical extents in the data, it was not possible to undertake a meaningful status or trend assessment for microplastics in surface waters while there was a lack of both evidence and robust assessment criteria to make a status assessment for beach litter and sea-floor litter. In a similar vein, due to the high variability in both the presence of potentially toxic phytoplankton above the threshold level, and the frequency and intensity of biotoxin events between 2010 and 2018, it was not possible to identify any discernible trend regarding an overall increase or decrease in the toxin contamination of shellfish. A further example is that the lack of assessment criteria and the small number of shellfish production areas in each SMR meant that it was not possible to present a status assessment by SMR for shellfish water microbiology.<sup>1</sup>

- Many contaminant concentrations are decreasing, but concerns remain.
- Biological effects of contaminants are observed, but are reducing.
- New methods to monitor and report on underwater noise are developing.
- Marine litter remains a problem, but with signs of improvement in some areas.
- Eutrophication is not an issue in Scotland's seas, but there are limited data on dissolved oxygen.
- Water quality at coastal bathing waters has shown a steadily improving picture since the 2006 EU Bathing Waters Directive was first reported in 2015.
- The environment and members of the public are adequately protected (i.e. doses are significantly less than the legal dose limit) from authorised disposal of radioactive waste.
- For some assessments, there are limited data or an absence of assessment criteria which prevents a full status assessment being undertaken, (especially at the scale of an SMR).
- There are savings to be made by utilising a cruise for multiple surveys (e.g. sea-floor litter data are collected during surveys designed to estimate the stocks of commercial sea-floor living fish) but this can limit the assessment that can be delivered for the survey which is not the main purpose of the cruise.



<sup>1</sup> see portal [Assessment processes and methods](#) page for information about regions used.

## Summary of knowledge gaps

The following knowledge gaps have been identified:

1. Methodologies to accommodate new challenges in national monitoring. These include how to:
  - Improve the incorporation of biological effects into assessments.
  - Improve the methods for the analysis of microplastics.
  - Incorporate emerging contaminants, such as pharmaceuticals and personal care products into monitoring programmes to guide future actions.
  - Establish the assessment criteria necessary to negate the need to use food safety levels for an environmental assessment.
2. The spatial coverage of the data at the SMR/OMR scale. These include:
  - Contaminant concentrations, particularly in sediment.
  - Biological effects of contaminants (EROD, external fish disease, imposex in dogwhelks).
  - Chlorophyll-a concentrations.
  - Near-bed dissolved oxygen concentrations.
  - Nutrient inputs, particularly riverine inputs.
  - Metal inputs from rivers.
  - Atmospheric deposition of metals.
  - Impulsive noise.
  - Shellfish waters microbiology.
  - Beach litter.
3. A full understanding of the impacts of radioactivity on the environment.
4. Measurement of impulsive noise for unlicensed activities such as some acoustic surveys.
5. The appropriate criteria for undertaking monitoring to ensure adequate cover, as highlighted for bathing waters, or to avoid the possibility of underestimation of toxin occurrence.



“Scotland’s seas are generally clean and safe and improvements are being seen, however, there is a lack of data in some areas, particularly for emerging concerns such as microplastics and noise.”

Lynda Webster, Topic lead

# Healthy and biologically diverse



More information on the regions used in the Healthy and biologically diverse assessment is available on the Assessment processes and methods page of the SMA2020 portal: <http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

**16**  
Assessments

**18**  
Case Studies

## Key words

seabirds  
citizen science seals  
strandings serpulid reefs  
commercial fish oysters shells  
salmon disturbance monitoring  
skates habitats shellfish sharks  
abundance food webs pressures  
priority marine features blue carbon  
waterbirds marine protected areas  
cetaceans intertidal seagrass rays  
trends survey ecosystem services  
deep-sea fish flame shells  
biogenic habitats deep sea  
non-native species  
continental shelf  
sea trout

## What is covered

The Scottish marine environment supports a spectacular and diverse range of habitats and species. Whilst much remains to be discovered, in recent years ongoing survey and monitoring work, as well as advances in underwater survey techniques, genetics and tagging technologies have resulted in significant improvements in the knowledge of the distribution of habitats and species, and their behaviour and connectivity.

To establish the health and diversity of Scotland's seas the status of a range of key habitats and species has been assessed:

- The population status and distribution of cetaceans and seals.
- The abundance and breeding success of a wide range of seabirds and numbers of overwintering waterbirds.
- The state of the populations of various commercial fish and shellfish as well as inshore fish, salmon and sea trout.
- The extent and status of the Scottish Marine Protected Area network.
- The scale and variety of non-native species found in Scottish waters and their rate of spread.
- The likely extent of disturbance to, and condition of, pelagic and seafloor habitats and species from fishing and other human activities.
- The status of seagrass beds and subtidal biogenic habitats.
- The progress in measures to protect Priority Marine Features (PMF) both inside and outside of Marine Protected Areas (MPAs).

## The basis of the assessment

The assessments of different habitats and species are reliant on various survey and monitoring programmes. For some components there are well tried and tested methodologies such as the biennial grey seal pup counts, and the harbour seal moult counts that are carried out on a rolling five-year cycle. Equally, breeding seabirds are monitored through the UK Seabird Monitoring Programme and non-breeding waterbirds through the Wetland Bird Survey (WeBS). The abundance of offshore cetaceans is assessed via a series of large-scale surveys (SCANS – Small Cetacean Abundance in the European Atlantic and North Sea) carried out

roughly every 10 years, whilst the east coast inshore bottlenose dolphins are the subject of a long-running, annual photo-id monitoring programme.

There are long-established programmes for monitoring commercial fish stocks which are evaluated on the basis of International Council for the Exploration of the Sea (ICES) areas rather than the SMRs and OMRs. *Nephrops* stock assessments are conducted annually by ICES whilst results for crabs, lobsters and scallops are based on Marine Scotland triennial assessments. The wider fish community is covered by the International Bottom Trawl Survey, whilst the deep-sea fish assessment is based on data from scientific trawl surveys. Salmon and sea trout assessments are based on catch returns and counts of returning fish on an individual river basis, and fish communities in transitional waters (i.e. estuaries and reduced salinity sea lochs) are surveyed by SEPA as part of the Water Framework Directive monitoring to assess Good Ecological Status. Changes in the plankton community are derived from the Scottish Coastal Observatory (SCObs) and the Continuous Plankton Recorder (CPR) surveys that provide both fixed point and track samples.

The extent of physical damage to seafloor habitats is based on modelling the exposure to pressures associated with demersal fishing activity as a proxy for habitat condition. Biogenic habitats are assessed largely based on surveys undertaken under the Scottish MPA Monitoring Strategy. Intertidal seagrass data are derived from the SEPA surveys. Other groups such as the non-native species are currently not subject to a regular national survey programme and assessments are based on incidental records or local targeted surveys in response to reports of a species occurrence. At a regional level there are good examples of coordinated monitoring programmes, e.g. work in Orkney, has enabled trends in occurrence and distribution of non-native species to be described.

Many of the programmes rely in part (and in some cases almost entirely) on the contributions by citizen scientists, made over many years. This includes counts and surveys of seabirds, waterbirds, seals, nearshore benthic habitats (e.g. Seasearch) and the reporting of non-native species.

## Summary of key messages

- The lack of sufficient data makes it difficult to report on trends for some species and habitats across Scotland (e.g. seagrass, biogenic habitats) and at a regional scale (e.g. waterbirds).
- Disturbance to seafloor habitats from bottom-contact towed fishing gear is estimated to affect at least 15% of the sea bed in all SMRs and seven of the 10 OMRs.
- The UK Marine Strategy 'no loss in extent' target for subtidal biogenic habitats (e.g. blue mussel beds, horse mussel beds, serpulid aggregations, cold water coral and maerl beds) has not been met in certain SMRs.
- The importance in terms of climate change mitigation of a range of marine habitats for carbon sequestration and storage is becoming increasingly evident.
- There have been significant changes in the plankton community over the last 30 years with potential implications for marine food webs.
- The abundance of some species of offshore cetaceans has remained stable, whilst the abundance of coastal bottlenose dolphins on the east coast has increased and their distribution has expanded.
- The grey seal population has increased and whilst the harbour seal population is largely stable, their number continues to decline in the North Coast and Orkney Islands SMRs.
- Since 2011, overall numbers of seabirds have largely been stable but are at a reduced level compared to the baseline values in 1986. Some species show markedly different trends (e.g. decreases in surface-feeding birds).
- Overall, 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.
- By the end of 2018, Scotland's MPA network comprised 231 sites covering 22% of the Scottish marine environment and progress has been made with the implementation of site-specific management measures. Following designations in December 2020 this increased to 37%.



“ We ignore Scotland's seas at our peril. Progress is being made in the protection and sustainable exploitation of this resource but more still needs to be done.”

John Baxter, Topic lead



## Summary of knowledge gaps

The following knowledge gaps have been identified:

1. The distribution and abundance of inshore fish communities (including transitional waters), including prey species relevant to marine mammals and birds.
2. Implications of the changes in distribution/ extent and abundance of species and habitats (e.g. pelagic) for the functioning of the wider marine ecosystem.
3. Trends in seabirds and waterbirds at the SMR/OMR scale.
4. The drivers of decline for some species (e.g. harbour seals, salmon and sea trout).
5. The effects of predation and natural mortality on commercial fish stocks.
6. Implications of climate change and ocean acidification for habitats and species and ecosystem services.
7. Seasonal changes in the distribution of cetaceans and seabirds (including key wintering areas for seabirds that breed in Scotland).
8. At-sea usage and habitat preferences of harbour and grey seals.
9. The presence and location of non-native species and how quickly they are spreading.



10. Pressure-thresholds relating to the impacts of human activities on habitats and species.

11. Trends in the distribution and extent of biogenic habitats across Scotland at both the national and regional scales.



## Overview of status and trends for habitats and species in Scotland's seas

### Few or no concerns

Bottlenose dolphin (North Sea)



Waterfowl



Harbour porpoise, white-beaked dolphin & minke whale



Commercial fish



Grey seal



Waders

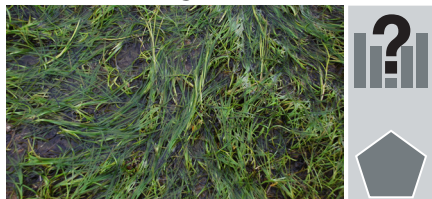


Commercial shellfish



### Lack of evidence / robust assessment criteria

Intertidal seagrass



Inshore fish (variable salinity)



Wider fish community



### Key to assessment results

- Few or no concerns
- Few or no concerns, but some local concerns
- Few or no concerns, but many local concerns
- Some concerns
- Some concerns, but many local concern
- Many concerns
- Lack of evidence / robust assessment criteria
- Lack of regional evidence / robust assessment criteria, but no or few concerns for some local areas

Some concerns

Many concerns

Harbour seal



Extent of physical disturbance to seafloor habitats



Seabirds



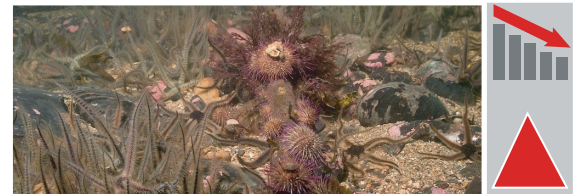
Plankton



Salmon and sea trout



Biogenic habitats



Deep-sea fish



Non-native species



Lack of regional evidence / robust assessment criteria, but some concerns for some local areas

Lack of regional evidence / robust assessment criteria, but many concerns for some local areas

Decreasing

No / little change

Increasing

No trend discernible

All trends

# Productive



More information on the regions used in the Productive assessment is available on the Assessment processes and methods page of the SMA2020 portal: <http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

**19**  
Assessments

**6**  
Case Studies

## Key words

**flood risk**  
**value management**  
**water historic environment**  
**abstraction** leisure and recreation  
 maritime transport **ship building**  
**sea trout** **mussels**  
**military** **dredging**  
**defence**  
**cultural heritage**

**gross value added**  
**carbon economics**  
**capture fish processing**

**coastal typology**  
**subsea cables**  
 oil and gas

**fishing**  
 offshore renewables **shellfish**  
**aggregates** **coastal erosion** **tourism**  
**employment aquaculture** **industrial outfalls**  
 freight **seaweed harvesting**  
 salmon

## What is covered

The Scottish marine environment is used by a wide range of businesses and individuals and provides a vital contribution to Scotland's economy. Many industries depend upon the marine environment directly. These include fishing and aquaculture. Many more rely indirectly on the sea for services including energy generation from offshore wind, marine renewables, maritime transport of goods and people or information and energy transfer through subsea cables.

The productivity of a wide range of industries that use or depend upon Scotland's seas has been measured using:

- The gross value added (GVA) as the main economic measure of productivity, using trends at both national and regional levels where possible. Gross value added is the value of goods and services produced minus the cost of raw materials and other inputs used to produce them. The figure is much smaller than the turnover of the sector.
- Employment trends over time at a regional and national level.
- Other economic measures such as farm gate value for aquaculture and energy generation for offshore renewables.
- Other supporting information that may indicate a change in productivity, particularly in the absence of more robust economic information. For example, number (for ferry passenger numbers), volume (for water abstraction), weight (for maritime freight, dredge material deposits and salmon and sea trout fishing) and length (for sub-sea cables).

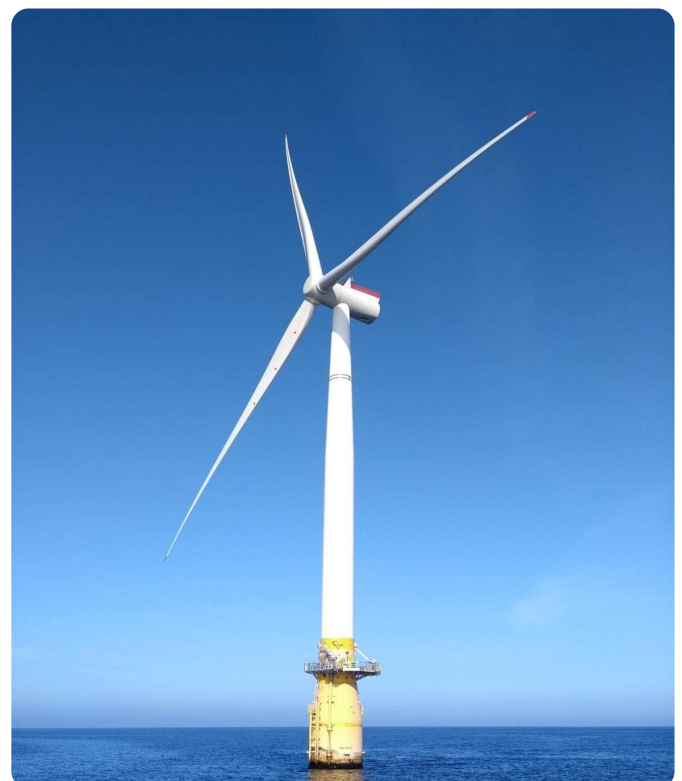
## The basis of the assessment

Due to the diverse nature of the industries assessed, a wide range of different sources have been used. In general, published government statistics have been used and links provided to the source publication, article or table. In some cases, particularly for new and emerging industries like seaweed harvesting and carbon capture, utilisation and storage, there is insufficient information to make an economic

assessment. In these cases the available information has been provided but no economic trends have been presented.

The main source for GVA and employment figures is the Scottish Annual Business Statistics (SABS) publication. This provides data on a number of economic variables across a range of sectors, based on data from the Annual Business Survey (ABS) conducted by the Office for National Statistics (ONS). The ABS sample is designed as a stratified random sample of UK businesses. To improve the quality of Scottish figures, the Scottish Government funds an enhanced ABS sample in Scotland, giving a total sample size of around 8,200 firms. However, it is not possible to provide regional breakdowns for every industry due to the small number of businesses sampled resulting in reduced quality and the risk of identifying information about individual businesses.

SABS publish information about sample sizes and error margins for the survey at: <https://www.gov.scot/publications/scottish-annual-business-statistics-2018/>



## Summary of key messages

The assessments cover a wide range of industries. Some, like oil and gas, are well established and are in long-term decline. Others, including tourism and aquaculture, are increasing productivity. New and developing industries, like renewables and carbon capture, utilisation and storage, are predicted to increase.

One of the key challenges is how to manage the competing demands for sea space between, for example, fishing, renewable energy, tourism and aquaculture. Often the use of the sea for one industry prevents its use by another. This means that an expansion and increase in productivity in one industry may lead to a decline in another. For example, opening a new wind farm could mean a potential decline in the fishing industry for that area. Part of this challenge is to find ways to reduce and avoid the impact of productive activities on the marine environment whilst maintaining productivity. Some measures are already in place to protect the marine environment, including: quotas for fishing; legislation; licensing; and the establishment of MPAs. However, over time these measures may need to change as more is known about the impact of productive activities on the marine environment and the effectiveness of existing measures.

- From 2014-2018, the overall fish tonnage landed in Scotland has decreased by 7%.
- The oil and gas sector is the biggest contributor to the marine economy representing two thirds of the entire marine sector GVA in 2017. Oil and gas production has increased since 2014 following a period of investment. However, it is in long-term decline but is expected to continue for a further 20 years.
- Between 2013 and 2017, aquaculture GVA increased by 58% to £354 million.
- Between 2008 and 2017, marine tourism GVA increased by 28% and employment by 16%.
- Between 2014 and 2018, Offshore wind (fixed and floating) and marine energy (wave energy and tidal stream) generation increased by 142% .
- There were 65 million tonnes of freight handled by all Scottish ports in 2018, down 9% since 2014.
- Ferry passenger numbers increased by 6% to 10.3 million and vehicles increased by 12% to 3.5 million between 2014 and 2018.

“The marine economy is important to Scotland, accounting for £14.7 billion Gross Value Added, 11% of the overall Scottish Gross Value Added in 2017.”

Venetia Haynes, Topic lead

## Summary of knowledge gaps

The following knowledge gaps have been identified:

1. Lack of key economic data on GVA and employment for a number of assessments, making productivity hard or impossible to measure. These include:
  - Comparable economic data even at a national level for coastal erosion and flood risk management, seaweed harvesting and cultivation, subsea cables, waste water treatment and industrial outfalls, and water abstraction.
  - Lack of data on GVA or employment at a national scale for dredge material disposal (weight used instead); offshore renewable energy (energy generation used); salmon and sea trout fishing (catch weight used).
  - Regional indicative economic trend data for historic environment and cultural heritage.
  - Lack of regional GVA data for maritime transport so tonnages are used for trends for freight and passenger numbers for ferries.
2. The data are often unavailable to investigate trends for Scottish Marine Regions and Offshore Marine Regions. In cases where a sub-national breakdown is possible this is often available at the scale of a local authority rather than for a marine region.

3. Although direct economic impact can be measured for many areas through GVA and employment, the wider social and economic impact of these industries is even harder to estimate. However, there is a need to understand the wider implications of a substantial increase/decrease in any industry, particularly for remote coastal areas, that may be dependent on a small number of marine industries for their livelihoods.



# Natural capital, ecosystem services and the blue economy



## 12 Assessments

### What is covered

Natural capital is the world's stocks of natural assets, including geology, soil, air, water and all living things. It encompasses the habitats and species that provide social, environmental and economic benefits to humans. Natural capital provides a common framework to bring together economic and social evidence and analysis for a particular subject or place ensuring that the value of the natural environment is given equal consideration. There is a need to balance the full costs of any human activity and this is why greater consideration is now being given to the ideas of natural capital and the blue economy.

The health of Scotland's seas is not only important for Scotland's wildlife and natural habitats, but also for the many benefits that people gain from the ocean, both locally and nationally. The viability of many marine and coastal businesses, from fishing to aquaculture and tourism, are inextricably tied to the condition of fish populations, the integrity of

the sea bed and the conservation of species, habitats and physical processes. Less obvious in people's day-to-day lives are benefits such as the production of oxygen, the incorporation and storage of carbon by species and habitats, the absorption of large amounts of excess heat, the protection of shores that are vulnerable to coastal erosion, and the cycling of nutrients and waste. Furthermore, the contribution that a healthy sea makes to personal physical and mental well-being should not be underestimated.

The specific aspects of nature that provide benefits for people are called 'ecosystem services'. They are grouped into four categories:

- Provisioning.
- Supporting.
- Regulating.
- Cultural.



To continue receiving these benefits from Scotland's seas, the impacts of human activities must not exceed nature's capacity to provide them and lead to the decline of Scotland's natural assets. To salvage benefits that have waned, or to safeguard those that appear vulnerable, management of specific activities to ensure the recovery of the features that underpin those services will be necessary.

The realisation of both the rate of change and the magnitude (geographically the whole of Earth) of the impacts from the alterations in the climate resulting from an increase in the concentrations of greenhouse gases (primarily, carbon dioxide, methane, nitrous oxide and fluorinated hydrocarbons) in the atmosphere has forced humankind to consider solutions that work with nature. Whether this involves

the restoration of habitats that provide coastal protection or undertaking actions to improve local biodiversity, nature-based solutions need to become mainstream.

This assessment explores ecosystem services with respect to a number of themes that are in line with the vision for Scotland's seas. The themes explored are:

- The physical and chemical marine environment and climate change.
- Productive seas.
- Clean and safe seas.
- Healthy and biologically diverse seas.
- Scotland's MPA network.
- Coasts and seas for human health.
- Social attitudes to the sea.

Natural capital and ecosystem services are fundamental concepts when it comes to managing human activities affecting Scotland's seas, although still viewed as relatively novel. They relate to both natural and social sciences, helping to strengthen links between science, policy and society.

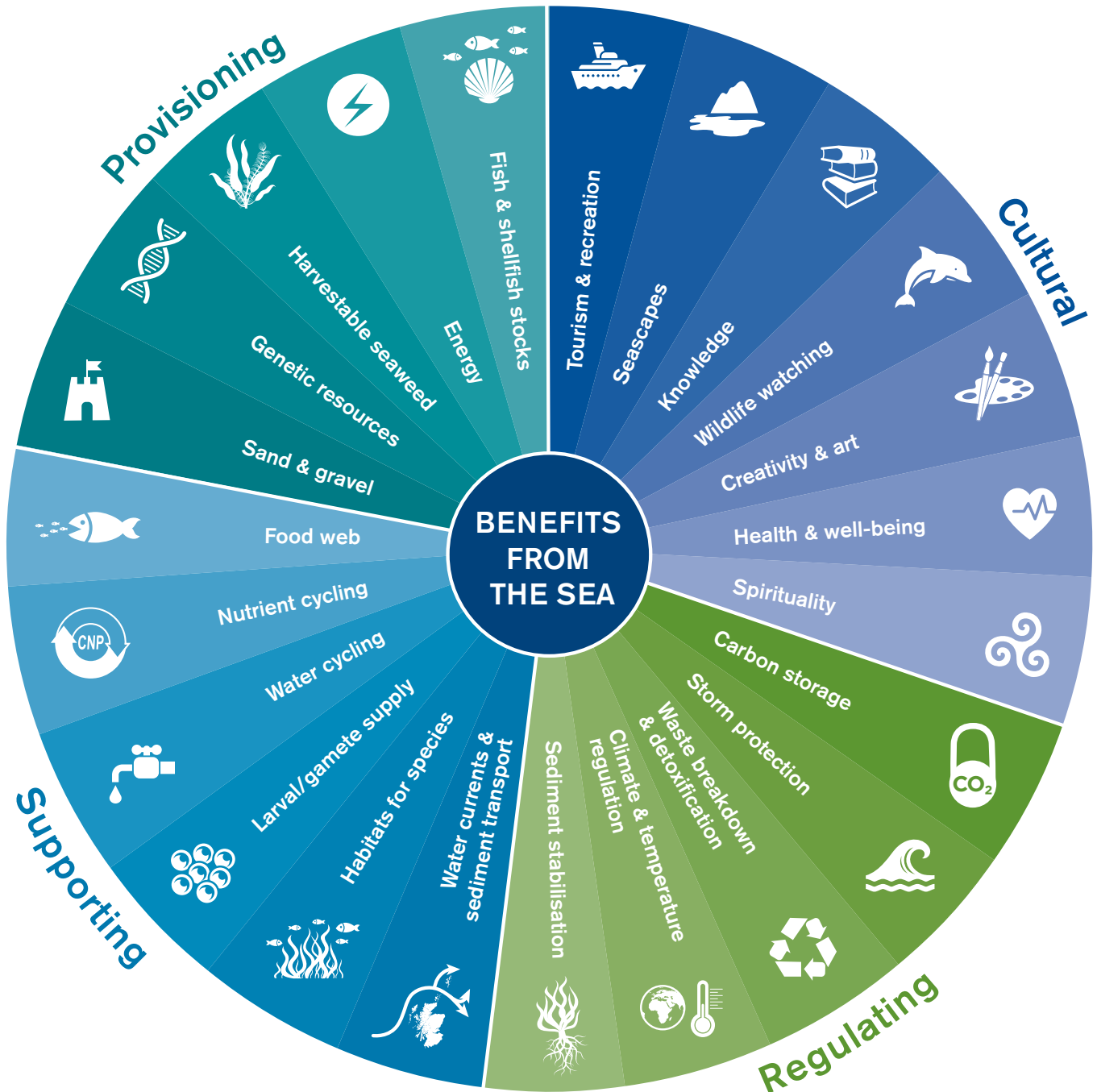


## The basis of the assessment












The details presented on natural capital, ecosystem services and the blue economy are based on published information with many examples also drawn from the other Topics presented in SMA2020, as well as from discussions around how natural capital, ecosystem services and the blue economy are being used by the Scottish Government and organisations such as NatureScot and SEPA.

There is a strong focus on the elements of the vision for Scotland's seas. In addition, understanding of the relationship between human health and the sea has been considered alongside the understanding of social attitudes towards the marine environment, based on a recent Scottish Government commissioned survey <https://www.gov.scot/publications/scottish-social-attitudes-2019-attitudes-government-political-engagement/>

## Provisioning, supporting, regulating and cultural – examples of ecosystems services from Scotland's seas



## Summary of key facts

|                     |  |
|---------------------|--|
| <p>Cultural</p>     |    <p>People who live near to or visit the coast and sea are more likely to be active and happy. In addition, people value the marine environment for leisure and recreation, providing a low-cost way to get outdoors, keep fit, look after mental health and entertain children. Visits to the beach and tourism are also good for the economy. The long-term trend from 2008 to 2017 showed marine tourism Gross Value Added increased by 28% and employment by 16%.</p> <p>Engagement with individuals and organisations greatly improves ocean literacy and facilitates action towards achieving the balance between exploitation and protection.</p>  |
| <p>Regulating</p>   |   <p>Seagrass meadows stabilise the sediment and help protect coastlines from erosion. Since 1970 the global ocean has taken up excess heat resulting from human activities that produce greenhouse gases in the climate system.</p>   |
| <p>Supporting</p>   |   <p>The Scottish Marine Protected Area (MPA) network, in 2018, covered approximately 22% of the seas around Scotland. Following designations in December 2020 this increased to 37%. The protected features of these MPAs, for example maerl beds and seagrass meadows, contribute to natural resources and ultimately benefit people.</p> <p>Scotland's beaches, kelp forests and salt marshes help protect £13 billion of coastal buildings and infrastructure. This compares to £5 billion protected by engineered sea walls.</p>  |
| <p>Provisioning</p> |     <p>The ocean provides about half the oxygen required by the planet due to the photosynthesis that occurs in the phytoplankton.</p> <p>The ocean is critical to life on land. Humans have reaped benefits from the seas for thousands of years and continue to benefit in many ways from the sea, including the provision of fish and shellfish, providing a valuable source of protein and the essential n-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA).</p> <p>New chemicals are being discovered, a common source being marine sponges. Some are anticancer agents. Others have anti-inflammatory properties or are analgesics. Several are in clinical use.</p> |

## Direct contributors to the blue economy



Farmed Atlantic salmon showed a production value of £878 million in 2018, 97% of total marine aquaculture value. Mussels are the main shellfish species produced, accounting for 6,874 tonnes in 2018.



In 2017, ship building and processing provided 7,700 jobs out of a total of 84,500 jobs in the marine sector.



Ports are a key part of the maritime infrastructure, providing the transport infrastructure between land and sea. Ports are critical in the effective movement of cargo and people especially in the context of today's global economy and the ever-increasing demands of the customer. Between 2014 and 2018, ferry passenger numbers increased in Scotland by 6% to 10.3 million and vehicles carried by ferry increased by 12% to 3.5 million.



Oil and gas production in the Scottish sector has increased from 59.96 million tonnes of oil equivalent in 2014 to 77.22 million tonnes of oil equivalent in 2018 as a result of investment. However, the trend in production is in long-term decline.



Offshore wind and marine renewables are technologies that utilise wind, tide and wave motion to provide humans with sustainable and renewable electricity without the production of greenhouse gases, and could provide economic benefits for Scotland. Between 2014 and 2018 offshore wind capacity in Scotland increased by 216%.

## Ecosystem services, the blue economy and climate change

The physical and chemical characteristics of the marine environment underpin the viability, distribution and functioning of species and habitats, and therefore the ecosystem services to which they contribute. As these characteristics change due to climate change, it is likely that habitats will be affected and species distributions will change. This will have consequences for the ecosystem services provided by the seas around Scotland and will impact the industries that are part of the blue economy.



## Examples of benefits for people

Benefits for people from deep-sea habitats

- Food & nutrition.
- Clean water & sediments.
- Knowledge.
- Spiritual/cultural.
- Jobs & business.
- Climate and temperature regulation.
- Carbon storage.

Benefits to people from shellfish and other invertebrates

- Health & well-being.
- Knowledge.
- Clean water & sediments.
- Spiritual/cultural.
- Jobs & business.
- Tourism & recreation.
- Food & nutrition.

“The benefits that we rely on from Scotland's seas are huge, from an economic perspective but also more broadly, for example we are increasingly recognising the contribution they make to our health and well-being.”

Katie Gillham, Head of Marine Ecosystems, NatureScot

## Next Steps

The inclusion of the concepts highlighted in this section into marine planning requires a number of steps:

- Development of methods to make the concepts of the blue economy, ecosystem services, nature-based solutions and natural capital practicable by being able to take account of issues relating to scale, location, connectivity, and local knowledge, including cultural values.
- Improvement in the understanding of some aspects of marine ecosystems including the distribution of some habitats and species, resilience, function and processes, trends, and responses and thresholds relating to human activities and climate change.
- Development of tools that embed the concepts of ecosystem services, nature-based solutions and natural capital in decision making processes.
- Investment in the underpinning science so that the distribution of benefits across society, and how human activities can be managed to maximise these benefits over the long term, are fully understood. Without this, decisions may not effectively take account of the trade-offs between different options to support the planning and sustainable management that will be the basis of a refreshed National Marine Plan.
- Communicating about the concepts of ecosystem services, natural capital, nature-based solutions and the blue economy to make sure they are well understood, thereby readily included in processes and planning.

# Pressures from activities and their management



## Key words

emergence regime  
qualitative approach  
siltation rate change  
expert judgement pressure  
barrier Scottish Marine Regions  
physical removal  
genetic modification  
collision contamination  
water flow change  
salinity change

light or shading  
removal of target species  
litter Offshore Marine Regions  
consensus building human activity  
temperature change reduction of prey  
wave exposure change visual disturbance  
Marine (Scotland) Act 2010 physical change  
non-native species electromagnetic change  
organic enrichment underwater noise  
removal of non-target species surface abrasion  
radionuclide contamination water clarity change  
physical loss sub-surface abrasion/penetration  
deoxygenation nitrogen & phosphorus enrichment  
feature activity sensitivity tool (FeAST)  
microbial pathogens (disease) viruses parasites

More information on the regions used in the Pressures from activities assessment is available on the Assessment processes and methods page of the SMA2020 portal:  
<http://marine.gov.scot/sma/assessment-theme/assessment-processes-and-methods>

21  
Assessments

## What is covered

Many different human activities take place in the seas around Scotland. Fishing, aquaculture, the movement of goods, the removal of hydrocarbons, capturing wind, wave and tidal energy, ecotourism, yachting, surfing, transport of materials through pipelines, transmission of power and communication through submarine cables, military manoeuvres and the development of ports and harbours are some of these activities. In addition, the marine environment is a sink for emissions and discharges from human activities. This can result in nutrients, hazardous substances and (often plastic) litter being discharged from point sources or entering marine ecosystems in a more diffuse manner via rivers and the atmosphere.

Under the Marine (Scotland) Act 2010, Scottish Ministers are required to prepare a summary of significant pressures and the impact of human activity on the area or region. To meet this requirement, a process was put in place to determine the top five human pressures in each of the 11 SMRs and 10 OMRs over the period 1 January 2014 to 31 December 2018. This assessment of pressures only considered those human activities that have a direct impact on the marine environment. Indirect pressures, such as the effects of greenhouse gas emissions, which indirectly influence the marine environment through [climate change](#) and [ocean acidification](#), are dealt with in other parts of SMA2020.

## The basis of the assessment

Although assessments of direct human pressures have been attempted in the past by marine managers across the globe, there is no formal process that is internationally recognised for delivering such assessments. In part, this is because the assessment of pressures resulting from individual human activities and then ranking the various pressures is fraught with challenges. To lessen some of these challenges, the process used in SMA2020, which used expert judgement as its basis, also utilised the [Feature Activity Sensitivity Tool \(FeAST\)](#) which aims to standardise definitions and linkages relevant to pressures and activities taking place in Scotland's seas.

NatureScot, JNCC and Marine Scotland developed FeAST in recent years in collaboration with industry, scientific experts and other stakeholders. The tool, through the use of standardised language on pressures and activities, highlights the nature of the pressures exerted by the various human activities taking place in the seas. FeAST was not designed to assess the intensity, frequency or cumulative impacts from activities taking place at specific locations.

Pressures were assessed singly, with multiple activities combining in some instances to affect the intensity and geographic distribution of a single pressure. The cumulative effect of multiple pressures on the marine environment was not considered within the assessment framework due to the complexity of the likely interactions (additive, synergistic and antagonistic) involved.

### A bespoke process was developed comprising three key stages:













1. Agreement on what activities actually occur in each SMR or OMR.
2. Pressure experts identified, scoped and ranked the pressures in each SMR or OMR.
3. Translation of these pressures back to the main pressure-causing activities and the production of a commentary on the trends in the pressures over the period 1 January 2014 to 31 December 2018.

Steps 2 and 3 were undertaken in a consensus building workshop held at the MASTS Annual Science meeting in October 2019 attended by 45 delegates.

## Main pressures identified as an outcome of the Pressure Assessment Workshop

The SMA2020 portal presents a pressure assessment for each of the 21 SMRs and OMRs. The tables highlight the top five pressures for each of the regions. The effects of climate change are considered elsewhere in SMA2020.

Key:


















































|  |  |
|--|--|
|  Removal of target species (including lethal)     |  Physical change to another sea bed type  |
|  Removal of non-target species (including lethal) |  Synthetic compound contamination including pesticides, antifoulants, pharmaceuticals |
|  Surface abrasion                                 |  Organic enrichment   |
|  Sub-surface abrasion/penetration                 |  Litter   |
|  Sub-surface/surface abrasion/penetration         |  Hydrocarbon contamination  |
|  Underwater noise                                 |  Death or injury by collision below water   |

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

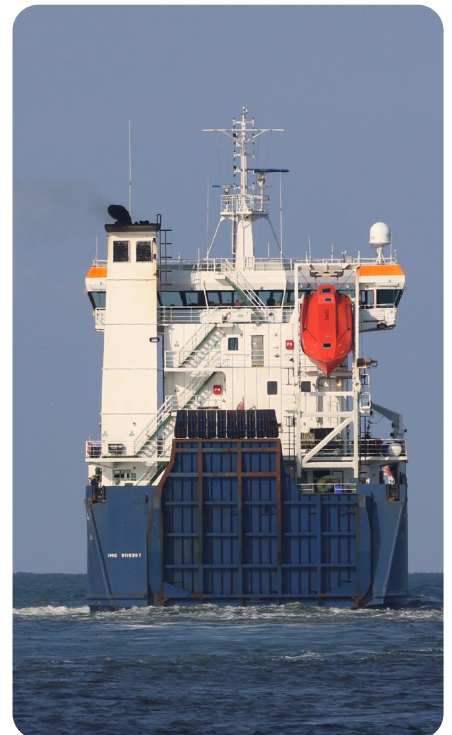
| Region            | Pressures ranked by declining severity from left to right                           |   |  |   |   |
|-------------------|---|---|--|---|---|
| S1 Forth and Tay  |  |  |  |  |  |
| S2 North East     |  |  |  |  |  |
| S3 Moray Firth    |  |  |  |  |  |
| S4 Orkney Islands |  |  |  |  |  |
| 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   |
|---|---|
| <b>01</b> Long Forties                    |                |
| <b>02</b> Fladen and Moray Firth Offshore |                |
| <b>03</b> East Shetland Shelf             |                |
| <b>04</b> North and West Shetland Shelf   |                |
| <b>05</b> Faroe Shetland Channel          |                |
| <b>06</b> North Scotland Shelf            |                |
| <b>07</b> Hebrides Shelf                  |     *   |
| <b>08</b> Bailey                          |                |
| <b>09</b> Rockall                         |      |
| <b>010</b> Hatton                         |      |

\* intentionally blank





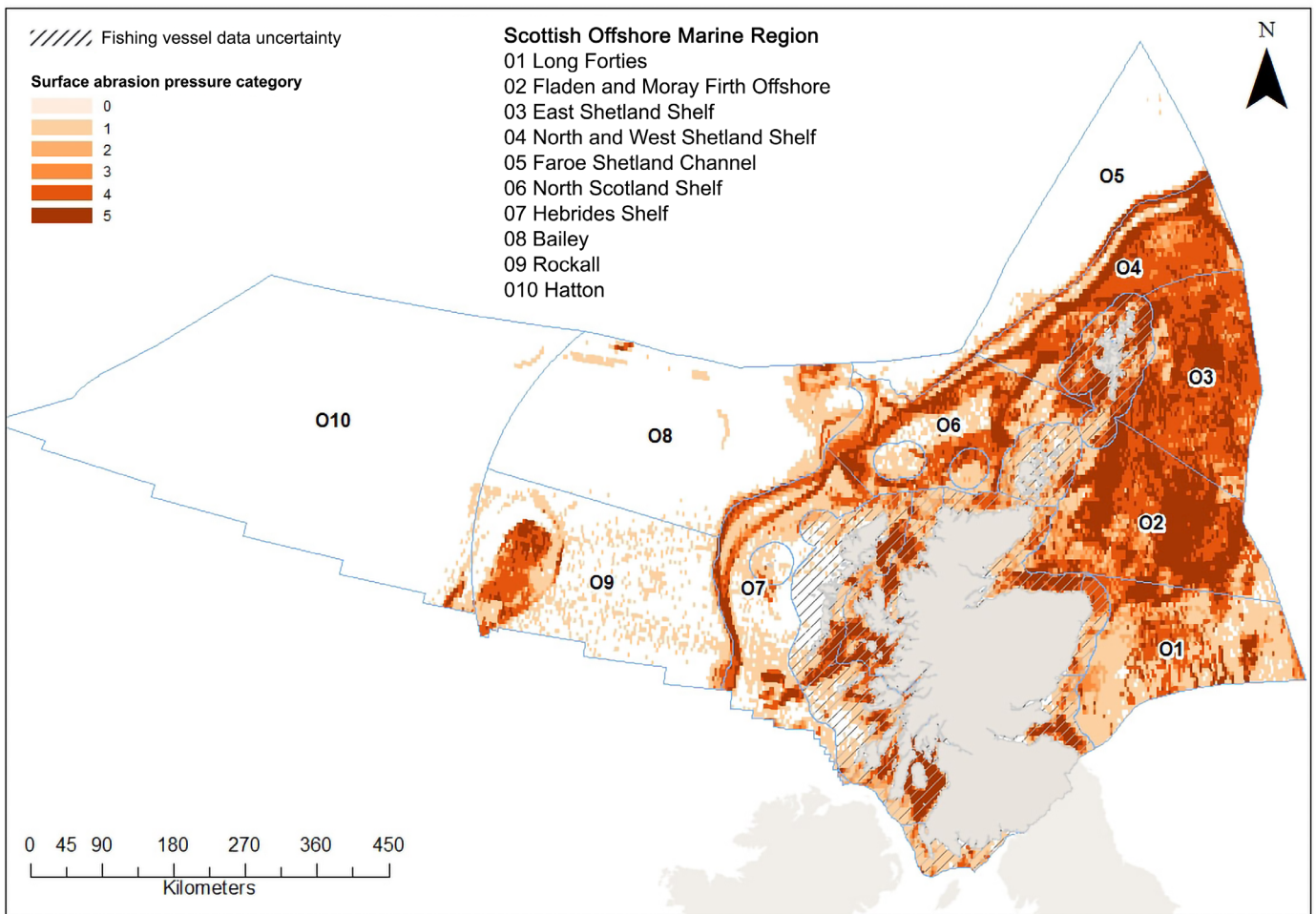
## Summary of key messages

- Fishing, especially methods that involve towed, bottom-contacting gear, is regarded as the most geographically widespread direct pressure-causing human activity across all SMRs/OMRs.
- Underwater noise is recognised in some SMRs as a top five pressure, although the measurement of this pressure and the assessment of its effect requires further development.
- The production of a full spatial assessment of pressures and activities is not yet possible due to a lack of data at the correct spatial resolution and the absence of an agreed methodology.



“Fishing, due to the size of its footprint and the nature of the activity, is the dominant pressure-causing activity in the marine environment.”

Philip Boulcott, Topic lead



Aggregated surface abrasion pressure in regions using 2012-2016 data series. Pressure unit is swept area ratio (the proportion of grid cell swept by fishing gear). Hash indicates inshore areas where fishing data are uncertain due to lack of information for small vessels. Figure from the *Predicted extent of physical disturbance to seafloor assessment*.

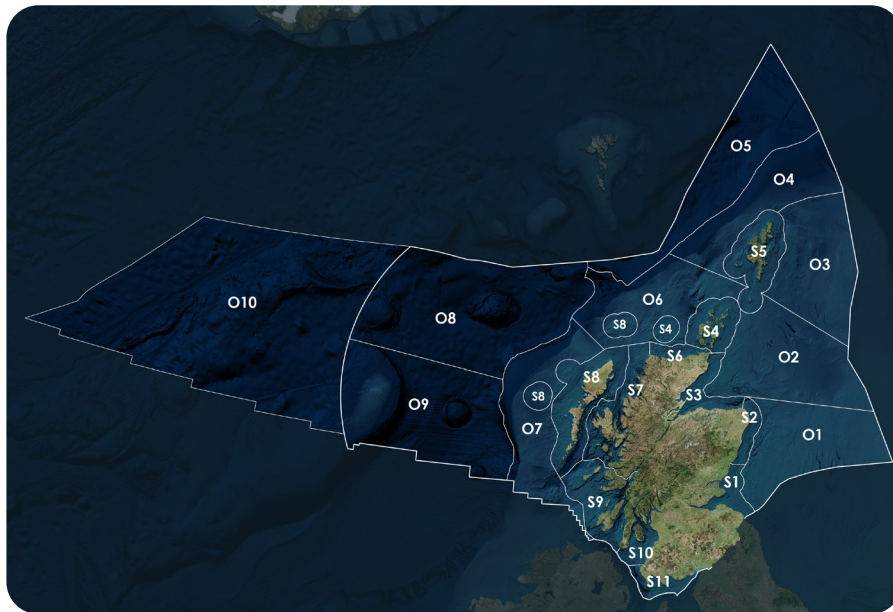
## Summary of knowledge gaps

The following knowledge gaps have been identified:

1. Data are often not presented at the SMR level. Highly resolved spatial data relating to both the status of biological features and pressures/activities are required.
2. Protocols for reporting within SMRs/OMRs for biological features that operate at much larger spatial scales, for example, cetaceans that range over large distances.

3. Lack of comprehensive mapping of some activities. For example fishing vessels below 12 m in length are excluded from Vessel Monitoring System data used to assess fishing activity.
4. The effect of some direct human pressures on the long-term condition of biological features. For example the effect of noise or marine litter on mortality rates across the marine ecosystem.

# Regional assessments



**21**  
Assessments

## What is covered

The regional assessments present findings and information from SMA2020's assessments and case studies relevant to the 11 statutory SMRs and/or the 10 OMRs where possible.

The regional assessments do not introduce new material, rather highlight relevant parts of the wide-ranging assessment under the headings:

1. Physical characteristics.
2. Human activities, past and present, that details what has happened in the region over the period 2014 to 2018.
3. Pressures from human activities, based on the Pressures from activities workshop.
4. Assessments, highlighting key findings from Clean and safe, and Healthy and biologically diverse Topics as well as identifying the Priority Marine Features in the region and their contribution towards the Marine Protected Area network.
5. Impacts of climate change on the region.



*All regional assessments include a satellite image to show the location of the SMR/OMR. This one for the Clyde SMR identifies the adjacent SMRs: Argyll; and Solway.*

# Key outcomes from the peer review



Scotland's Marine Assessment 2020 has been subjected to a rigorous peer review. This was viewed by Scotland's Seas Data Assessment Group (SSDAG) as an essential component of the delivery of a robust assessment. The peer reviewers provided detailed comments on all aspects of SMA2020. These were returned to the authors who then responded to the comments. The peer reviewers were asked to respond to a number of questions. Specifically that the assessment:

1. Satisfied the requirements, Section 5 (4) (b) and (c), of the [Marine \(Scotland\) Act 2010](#).
2. Supported the National Marine Plan vision for the marine environment: 'clean, healthy, safe, productive, biologically diverse marine and coastal environments, managed to meet the long-term needs of nature and people'.
3. Adequately covered the subject areas/sectors of the National Marine Plan.
4. Contained useful and appropriate status and trend information.
5. Contained information focused on the statutory Scottish Marine Regions as well as the non-statutory Offshore Marine Regions.

6. Contained material to support the 'Climate Change – Evidence Base' statements in the National Marine Plan.

7. Contained material to support an ecosystem-based approach.

8. Contained material to support the United Nations Sustainable Development Goals and the Scottish [National Performance Framework](#).

The peer reviewers concluded that SMA2020 satisfied the requirements of the relevant sections of the Marine (Scotland) Act 2010, supported the National Marine Plan vision and contained the necessary material to support the various statements and goals.

The peer reviewers provided a range of useful comments on the various topics, assessments and chapters. These were taken into account in finalising the material available on the SMA2020 Portal and contained within this document. SSDAG would like to acknowledge the considerable contribution of the peer reviewers to the final product.

## Lessons learned

The future challenges that will have to be overcome to secure a clean, healthy, productive and biologically diverse ocean have been identified. These include having the data and understanding, coupled with the development of new indicators underpinned by long-term monitoring, that will result in a future assessment of Scotland's seas describing the condition of Scotland's marine environment and the pressures it is subject to. However, having the data is only one of several steps that are required to deliver a full assessment such as SMA2020. During the process of producing SMA2020 there have been a number of lessons learned, specifically in the context of producing the assessment. These are presented below.

### **Review the relevant scale for assessments:**

The scale at which to report continues to be debated whenever an assessment is being prepared, be it national or international. For an assessment such as SMA2020, there is an expectation that the scale of reporting will have a strong regional component, yet for topics including climate change, ocean acidification and cetaceans this may be neither appropriate nor possible, given the available data. A review and prioritisation of the gaps that need to be addressed at a regional scale should be undertaken to help inform development of the next SMA.

### **Refine current indicators and develop new indicators:**

SMA2020 presents the outputs from new indicators as well as those that are tried and tested. However, there continues to be a need to refine the existing set on the basis of their ease of use, availability of data and relevance to the questions being asked. In addition, there is a need to develop new indicators, especially where the questions have changed or the relevance of a component in the ecosystem has increased.

### **Improve the methods for assessing pressure from activities:**

The process for determining the pressures from human activities was structured and based around a tool (FeAST) developed in Scotland. However, a bespoke method needs to

be developed, linked to the framework provided by FeAST, to enable quantitative outputs and provide trends at an appropriate scale.

### **Scotland must continue to actively participate in national and international discussions:**

There are, for example, legacy issues which should influence on-going discussion on monitoring programmes, including for persistent organic pollutants, while taking account of more recent contaminants including personal care products and pharmaceuticals. The SMA2020 has built on and benefited from the results of these wider collaborations.

**Changing resource landscape:** Since the publication of Scotland's Marine Atlas in 2011, new data have become available and additional programmes have been introduced. However, the scale or frequency of sampling of some existing monitoring programmes have been reduced. Unless addressed, this will continue to impact on the quality of future assessments. The developing Scottish Marine Science Strategy needs to take account of the changing landscape in identifying the priorities.

**Style is critical:** SMA2020 is an electronic product aimed at a broad audience of policy makers, decision-takers, specialists and the general public. The current SMA guidelines focus on technical aspects. The instructions to the authors of future assessments must be more definitive in terms of providing a style guide on how to write content for these audiences across a range of digital media.

**Sourcing relevant images:** Electronic delivery requires a greater number of relevant images, which it takes time to source. It may be useful to identify the most significant gaps, so such gaps have been filled in advance of the next SMA.

### **It always takes longer than you think:**

SMA2020 has required the input of many people (more than 250). A thorough and valuable peer review, critical to the final output, also takes time.



The future of life on Earth depends on the ocean. Engaging with younger generations and encouraging them to take a deep interest in marine issues is of fundamental importance as they will inherit stewardship of the ocean and the challenges that brings.



Sunnyside Ocean Defenders, pupils at Sunnyside School of Conservation in Glasgow, are ambassadors for the ocean. They bring huge passion and enthusiasm to designing their campaigns aimed at protecting the ocean.



Prof. David Paterson, Executive Director of the Marine Alliance for Science and Technology for Scotland, (far left) leads a group of students from the University of St Andrews on a research field trip.



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