OSPAR COMMISSION

Fish Thematic Assessment

OSPAR

QUALITY STATUS REPORT 2023

2023

OSPAR's Quality Status Report 2023

Fish Thematic Assessment

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998. The Contracting Parties are Belgium, Denmark, the European Union, Finland, France, Germany, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Convention OSPAR

La Convention pour la protection du milieu marin de l´Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d´Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998. Les Parties contractantes sont l´Allemagne, la Belgique, le Danemark, l´Espagne, la Finlande, la France, l´Irlande, l´Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume- Uni de Grande Bretagne et d´Irlande du Nord, la Suède, la Suisse et l´Union européenne

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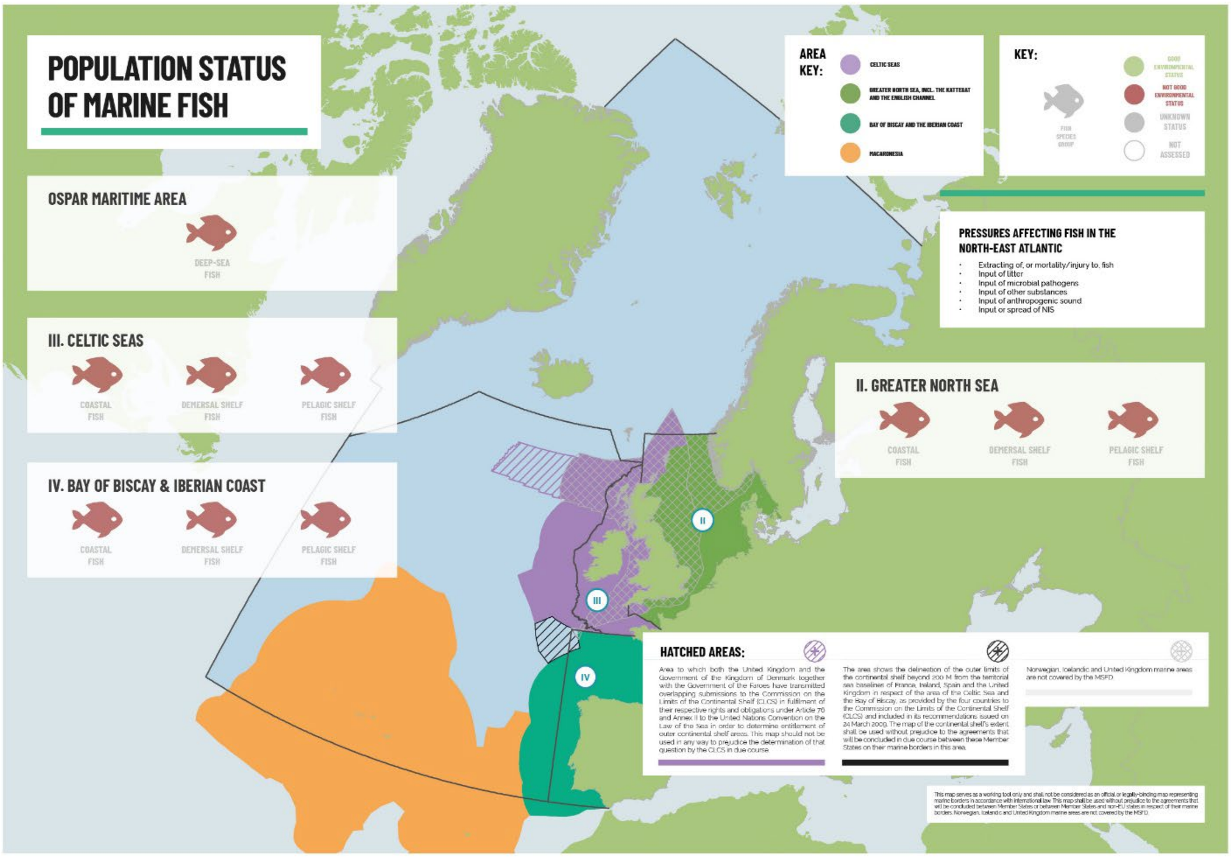
Executive Summary

Fish are an essential part of the marine ecosystem, providing many ecosystem functions. Society has a need for fish as a vital source of food. Commercial fishing provides for that societal need. Fisheries management in the North-East Atlantic aims to maintain fish stocks at healthy levels. An integrated assessment of species/stock status found that marine fish were not in good environmental status, despite the improving status of many individual fish stocks over recent years. This finding was common to coastal, demersal and pelagic fish in the Greater North Sea, Celtic Seas, Bay of Biscay and Iberian Coast Regions and for deep-sea fish across the OSPAR Maritime Area. A separate assessment for the Norwegian waters in OSPAR Arctic Waters showed mixed results, with commercial stocks in both good and not good status. The overall status of fish was assessed by integrating the OSPAR common indicator for the recovery of sensitive fish species with third-party assessments of commercial fish stocks produced by the International Council for the Exploration of the Sea (ICES) and the International Commission for the Conservation of Atlantic Tunas (ICCAT). This is the most comprehensive fish status assessment by OSPAR to date, and the first to integrate commercial fish stocks.

The regulation of fishing activities lies outside of OSPAR's competence, but a requirement to cooperate with other competent bodies is set out in Article 4, Annex V of the OSPAR Convention and this is an explicit objective of the North-East Atlantic Environment Strategy (NEAES) 2030. Fisheries management regulations have successfully brought the harvesting of some fish stocks to sustainable levels, but many stocks are still overexploited. Measures are now also being taken with an ecosystem perspective, including the introduction of some intended to protect vulnerable habitats and species. However, concerns remain, including in relation to by-catch of sensitive/non-commercial species, the need to integrate concepts of ecosystem function into fisheries management regulation – such as the idea of trophic cascades – and how management regimes can take account of the impact of fisheries on the pelagic habitat and food webs. For its part, OSPAR has focused on 22 fish species that are considered to be under threat and/or in decline in the North-East Atlantic and has taken national and collective actions to protect and conserve almost all of these species. With the exception of some skates and rays, most of the OSPAR listed fish species are assessed as having poor status and there are still gaps in the OSPAR Marine Protected Area (MPA) network for almost all of the fish species on the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR Agreement 2008-06).

In response to the findings of this assessment, OSPAR will initiate discussions on regional-scale ecosystem-based management, including through the 'Collective Arrangement' and in cooperation with fisheries management bodies and other competent organisations; this will include initiatives to minimise, and where possible eliminate, incidental by-catch of fish.



Q1. Identify the problems? Are they the same in all OSPAR Regions?

Fish are an essential part of the marine ecosystem, providing many ecosystem services. This means that the good health of fish communities has a positive effect on the marine food web and, conversely, that poor health will have a negative effect. Society has a need for food, and fish are a vital source of protein, which means that many species are targeted by fishing activity in the North-East Atlantic. The removal of these target species can result in reduced prey for other species, thereby affecting food web dynamics and relationships between species. Mortality through fishing activity can reduce the biomass of fish populations to unsafe levels and affect the age structure of populations by reducing the proportion of older and larger individuals.

A variety of fishing methods are utilised, depending on the target species. While all have the potential to remove non-target species, negatively impacting fish species of conservation concern such as sharks, skates, and rays as well as other species such as marine mammals and seabirds, these impacts vary greatly according to the gear used. Fishing methods which contact the seabed cause physical disturbance which can result in habitat loss, impacting fish species diversity, reducing prey, and affecting fish survival. This can severely impact OSPAR listed threatened and/or declining habitats such as *Lophelia pertusa* reefs and maerl beds. Bottom-trawl and dredge fisheries also cause sediment re-suspension, which can affect the availability of seabed species to the fish that feed upon them.

Climate change can impact marine fish by altering reproductive output, by changing the distribution patterns of species and by changing growth and mortality.

Society's need for the infrastructure associated with a range of activities such as energy generation, coastal defence, land claim and aggregate extraction can negatively affect fish habitat and migration routes. The infrastructure needs for energy generation are expected to increase significantly in the next decade.

In the 2010 Quality Status Report (QSR) it was reported that fishing pressure had a considerable impact on marine ecosystems, with many fish stocks reported as still being outside safe biological limits. The 2017 Intermediate Assessment indicated that there were signs of recovery in fish populations.

Trawlers in the North Sea. © Shutterstock

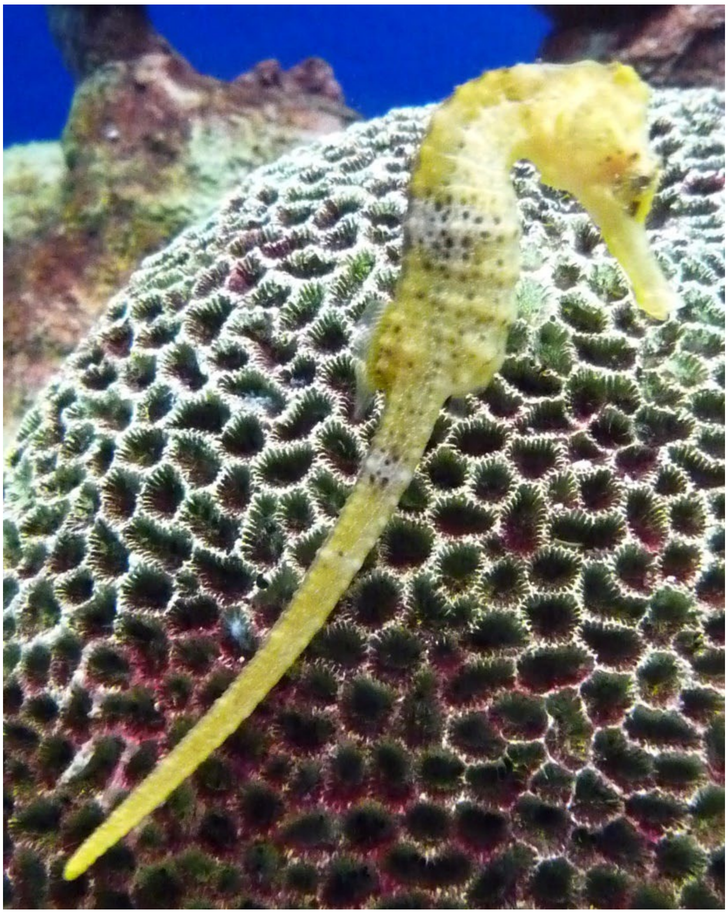
Q2. What has been done?

The dominant pressure on fish populations in the North-East Atlantic is the extraction of biomass through fishing activities which lie outside of OSPAR's competence to manage, as set out in Article 4, Annex V of the OSPAR Convention; this requires cooperation with other competent bodies, an explicit objective of the NEAES 2030.

OSPAR has listed 22 fish species (mostly non-targeted) that are considered to be under threat and/or in decline in the North-East Atlantic and has taken national and collective actions to protect and conserve almost all these species.

Fisheries management regulations have resulted in the harvesting of more fish stocks at levels considered sustainable for those stocks and in a shift of focus from fish stock management to an ecosystem perspective under which measures to protect vulnerable habitats and species are being introduced. However, concerns remain, including issues relating to by-catch.

There have been instances of Marine Protected Areas being put in place by some Contracting Parties in order to protect vulnerable fish.



Marine Protected Area coverage is considered as being ecologically coherent for long snouted seahorses. © Monterey Bay Aquarium

Q3. Did it work?

With the exception of some skates and rays, most of the OSPAR listed fish species are assessed as having poor status, and there are still gaps in the OSPAR MPA network for almost all of the fish species on the OSPAR List. The coverage is considered as being ecologically coherent only for houting, long snouted seahorses, allis shad and salmon, among the species for which MPAs may be a useful management tool.

Fisheries management regulations have resulted in many successes in the harvesting of fish stocks at levels considered sustainable, and in rebuilding stocks to healthy levels. However, overall good environmental status has not been achieved for fish population status. Another development has been a shift from fish stock management to an ecosystem perspective, with the introduction of measures to protect vulnerable habitats and species. However, concerns remain, including in relation to by-catch, the need to integrate concepts of ecosystem function into fisheries management regulation – such as the idea of trophic cascades – and how management regimes can take account of the impact of fisheries on the pelagic habitat and food webs. Further work to progress the alignment of fisheries management and environmental protection responses is also required.

Q4. How does this field affect the overall quality status?

The overall situation in which fish groups across the various assessed areas are not in good environmental status has wider implications for the marine ecosystem. Fish provide many ecosystem services, and consequently the status of fish populations has implications for the wider ecosystem. Fish play a role in regulating the balance of the food web. The degree to which fish influence the regulation of food web dynamics can vary depending on the physical and climatic conditions to which they are subjected.

The ecosystem service of providing biomass that can be harvested by humans (wild fish and other natural aquatic biomass and related raw materials) can also be affected in ways that lead to shifts in commercial fisheries. Such shifts can include extra fishing pressure on vulnerable components of the marine ecosystem. Reduced fish biomass also impacts feeding opportunities for other ecosystem components such as birds and mammals. Reduced fish population abundance and biomass can lead to a decrease in carbon fixation by the marine ecosystem.

Q5. What do we do next?

Two of the key objectives under the NEAES 2030 are particularly relevant. First, as a cross-cutting issue, OSPAR will initiate discussions on the development of a practical approach for regional-scale ecosystem-based management, including through the 'Collective Arrangement' (Agreement 2014-09) and in cooperation with fisheries management bodies and other competent organisations, in order to strengthen ecosystem resilience to climate change and to safeguard the marine environment, its biodiversity and ecosystem services (SX.O2). Also, OSPAR has set out to implement MPAs as well as other effective area-based conservation measures (OECMs) (S5.O1).

In addition, "*OSPAR will work with relevant competent authorities and other stakeholders to minimise, and where possible eliminate, incidental by-catch of marine mammals, birds, turtles and fish so that it does not represent a threat to the protection and conservation of these species and will work towards strengthening the evidence base concerning incidental by-catch by 2025*" (S7.O6). This will give increased attention to the effects of incidental by-catch, including for protected fish species. OSPAR should also take into consideration relevant by-catch studies in the framework of OSPAR, the European Commission and ICES and their conclusions.

Other areas for potential OSPAR response could include:

- Closing the gaps in the OSPAR MPA network for the fish species on the OSPAR List;
- Progressing the work of understanding the management effectiveness of MPAs, and sharing experience and best practice on management actions that best achieve the conservation objectives as they relate to fish communities;
- Mitigation responses that support job changes in areas where fishing industry has declined;
- The restoration of certain habitats to produce co-benefits for some fish species (Benthic Habitats Thematic Assessment);
- Examining the implications of removing fish from the wild (wrasse and lumpfish) for use as cleaner fish to manage parasite levels in farmed fish, including the genetic interaction of escaped cleaner fish; this has been identified by ICES as worthy of further investigation (ICES, 2020).

The effective implementation of many of these objectives will depend heavily on national action, which should continue to be reported through, for example, the implementation reporting requirements of OSPAR's Recommendations on threatened and declining species and habitats (next reporting due in December 2025).

OSPAR recognises the need to increase its focus on identifying and implementing collective actions which add value both to existing national actions and to the efforts of other international organisations. Overall, the 2019 implementation reporting indicates that there is a good level of engagement to implement the national actions within the OSPAR Recommendations, in particular within the areas where the species and habitats are considered to be under threat and/ or in decline. The level of engagement in collective actions is clearly lower, with some of the more complex actions not having been progressed and implemented. Many of these actions focus on monitoring and assessment and relatively few on response, but in both cases there has been only modest progress. OSPAR will therefore develop a series of biodiversity action plans, starting with marine birds and coastal shelf benthic habitats, in order to identify priority response measures which are well-defined, add value and can be delivered within the resources available to the OSPAR Contracting Parties.

The 2023 QSR provides a powerful evidence base for action. OSPAR will strengthen its capacity to use this evidence base, and all future assessments, to support engagement with other international partners. Engagement cannot be an end in itself: the development of a practical approach to ecosystem-based management (EBM) will provide the opportunity and the mechanism to share evidence and common objectives for a more sustainable use of the marine environment. Working with interested partners and drawing on international best practice, OSPAR will design and implement a pilot project on EBM in one of the OSPAR Regions.

Progress against all of these challenging objectives for biodiversity will be tracked through OSPAR's NEAES 2030 Implementation Plan. A planned review in 2025 will provide an opportunity to adjust OSPAR's NEAES 2030 and, if necessary, OSPAR will take further action to protect and conserve biodiversity.

D - Drivers

Social and economic drivers for activities affecting marine fish

The growing needs of society in times of global change are impacting marine fish on many levels. The increasing demand for energy drives the use of the fossil fuels that contribute to climate change, or the development of infrastructure to exploit renewable energy. As the global population expands, so does the demand for food. This has a direct impact on marine fish populations, which are targeted and exploited as a source of protein that has a lower carbon footprint than many terrestrial counterparts. Alongside these, the need for materials (to support the demand for housing and utilities, for example) directly impacts the marine habitats that many marine fish rely upon.

All social and economic drivers have the potential to influence the quality status of fish.

Growing population increases Society's need for energy. The introduction of infrastructure associated with renewable and non-renewable energy to the marine environment has the potential to either directly or indirectly affect fish. Localised temperature changes associated with power station inputs (e.g., water used as a coolant) may alter the distribution and abundance of fish and their food sources. Energy security activities may also drive impacts on fish, such as modifications made to water courses or arising from renewable energy installations.

Public recognition of the importance of healthy fish populations for the maintenance and enhancement of biodiversity is critical. Threats to fish species drive public pressure on political debate and action because of Society's needs and appreciation of nature and biodiversity.

Many factors driving activities that create climate change impacts, such as the burning of fossil fuels, industrialised farming practices and deforestation, are also driving impacts on fish. Society's need to mitigate the effects of climate change has led to the expansion of renewable energy technologies. These will result in the introduction of associated infrastructure to the marine environment which can either directly or indirectly affect fish species and habitats. Coastal and flood protection; sea defences; levees and dikes are being increasingly introduced, driven by Society's need to adapt to the effects of climate change. Again, such infrastructure has the potential to either directly or indirectly affect fish species and their habitats.

The production of goods and services contributes to Society's need for stable economies. The manufacturing and processing of goods can introduce pollutants to the marine environment which can affect fish either directly or indirectly.

Society's need for the trade and movement of goods drives the manufacturing and processing of goods, their shipment by sea, and navigational dredging in support of shipping. However, each can contribute to the input or remobilisation of contaminants in the marine environment. Vessel movements may disturb fish.

Fishing is a direct response to Society's need for food. Policies focus on fishing at sustainable levels to protect fish stocks; however, some practices lead to adverse impacts on the marine ecosystem that require management. Marine fisheries also need to be considered as a potentially low impact, low carbon human food protein source by comparison with some other terrestrial food protein sources.

Populations demand goods, which require manufacturing and processing, and services such as waste treatment and disposal. These are driven by Society's need for health and wellbeing. However, these activities can introduce pollutants to the marine environment. As part of a healthy diet, the WHO recommends that unsaturated fats (found in fish, among other foods) are preferable to saturated and trans fats.

Growing populations are increasing the demand for housing and utilities, and therefore increasing Society's need for materials and their processing. The manufacturing and processing of goods can introduce pollutants to the marine environment. Activities such as mineral extraction and infrastructure installation result in the restructuring of seabed morphology, which can drive impacts on fish habitats.

Cod and salmon on sale in a fishmonger. © Shutterstock

A – Activities

Activities exerting pressures on marine fish

Human activities are distributed widely across the North-East Atlantic, but the intensity of activities and of the pressures they impose on the marine environment vary greatly between OSPAR Regions and sub-divisions. Some sea areas are affected by multiple activities; in others, only a few may be significant. The table below, taken from the Human Activities Thematic Assessment, gives a high-level summary of the intensity and trends of selected activities across the OSPAR Regions, based on analysis in the feeder reports.

Activities like aquaculture, the renewable energy sector and tourism have increased in intensity since the QSR 2010, and are projected to further increase by 2030 (**Table A.1**). Other activities, like fisheries, have increased in the Celtic Seas and North Sea areas but have remained stable in recent years in the Bay of Biscay and Iberian Coast, and Wider Atlantic.

Overall, fisheries are the activity that has the highest direct impact on marine fish, through the removal of wild organisms which can be an exploited target species or through by-catch. Transport and shipping is the second most significant activity, impacting marine fish in several ways through the input of litter, pollution and pathogens.

Table A.1: Intensity and trends of selected human activities in OSPAR Regions. Cell entries represent intensity (high, medium, low), trend since QSR 2010, and forecast trend to 2030. The symbol ↔ is used where there has been little change in intensity since QSR 2010; the symbol ? is used where future trends are uncertain. (Source: Human Activities Thematic Assessment)

Main activities	Arctic Waters	Greater North Sea	Celtic Seas	Bay of Biscay and Iberian Coast	Wider Atlantic
Fisheries					
Intensity	H	H	H	M	L
Trend since QSR2010	↓	↑	↑	↔	↔
Trend to 2030	?	?	?	?	?
Aggregates extraction					
Intensity	L	H	M	M	L
Trend since QSR2010	↔	↓	↔	↑	↔
Trend to 2030	?	?	?	?	?
Agriculture					
Intensity	L	H	M	M	L
Trend since QSR2010	↔	↔	↔	↔	↔
Trend to 2030	↔	↔	↔	↔	↔
Aquaculture					
Intensity	H	H	M	M	L
Trend since QSR2010	↑	↑	↔	↑	↑
Trend to 2030	↑	↑	↑	↑	↑
Oil/gas production					
Intensity	M	H	M	L	L
Trend since QSR2010	↔	↔	↔	↔	↔
Trend to 2030	↔	↔	↔	↔	↔
Renewable energy					
Intensity	L	H	M	L	L
Trend since QSR2010	↑	↑	↑	↑	↔
Trend to 2030	↑	↑	↑	↑	↔
Shipping					
Intensity	M	H	H	H	L
Trend since QSR2010	↔	↔	↔	↔	↔
Trend to 2030	?	?	?	?	?
Tourism					
Intensity	L	H	M	H	L
Trend since QSR2010	↑	↑	↔	↑	↑
Trend to 2030	↑	↑	↔	↑	↑

Human activities that interact with fish are:

Fish and shellfish harvesting (professional, recreational) [Extraction of living resources]: Society's need for food is a driver for fishing activity. Gears used to extract living resources may directly / indirectly interact with fish species, altering fish populations. (OSPAR Feeder Report 2021 - Fisheries).

Renewable energy generation (wind, wave and tidal power), including infrastructure, Nuclear energy and Transmission of electricity and communications (cables) [Production of energy]: Renewable energy is the only activity driven by society's need to mitigate the effects of climate change, while society's needs and its appreciation of nature and biodiversity drive both renewable energy and nuclear energy. Fish are mostly impacted by the construction of renewable energy infrastructure, namely dredging of the seabed (physical loss or disturbance of the seabed) and underwater noise. The input of other forms of energy is also associated with this activity, mostly in relation to the electromagnetic fields originating from the cables and lighting. Nuclear energy is often located on the coast. Some form of cooling water intake/outfall is usually present, often with pipes running into sub-tidal areas. This directly interacts with fish habitat and fish can become caught in the water intake/outfall.

Extraction of oil and gas, including infrastructure and Extraction of minerals [Extraction of non-living resources]: Society's needs for energy and stable economies are both drivers for the extraction of oil and gas. Society's need for materials drives the extraction of minerals. Oil and gas exploration, operation and decommissioning, and the associated infrastructure (pipeline and cables), directly interact with fish habitat through anthropogenic sound input and seabed loss/disturbance. Mining can affect fish and aquatic resources through mine tailing depositions into the sea, bottom erosion and sedimentation, the de-watering of wetlands, the diversion, channelling and flow alteration of streams, and the contamination of surface water and aquifers with toxic chemicals; all of these can alter fish habitat. Marine aggregate extraction can similarly impact fish spawning grounds.

Coastal defence and flood protection, Land claim, Canalisation and other water course modifications and Restructuring of seabed morphology, including dredging and depositing of materials [Physical]: Coastal and flood defences are driven by society's needs for and appreciation of nature and biodiversity and its need to adapt to the effects of climate change. Land claim and watercourse modifications are driven by society's need for stable economies. The dredging and deposition of materials are driven by society's need for trade and the movement of goods. All these activities directly alter fish habitat. They can also impact migratory paths, particularly those of diadromous fish.

Transport shipping and Transport infrastructure [Transport]: Society's need for trade and the movement of goods drives transport, based on the need for stable economies and the supply and demands of goods and services. Transport directly interacts with fish habitat.

Marine aquaculture, Freshwater aquaculture, Agriculture and Forestry [Cultivation of living resources]: Society's need for food drives marine aquaculture, freshwater aquaculture and agriculture. Society's need for materials drives forestry. The cultivation of living resources contaminates the water with extra nutrient input and toxic chemicals, which can alter fish habitat. Aquaculture can also introduce diseases and parasites that may impact wild fish.

Tourism and leisure infrastructure and Tourism and leisure activities [Tourism and leisure]: Society's need for health and wellbeing drives tourism and leisure. Tourism and leisure structures and activities can be located in, on or adjacent to fish habitat.

Industrial uses [Urban and industrial uses]: Society's need for materials drives industrial uses. Sewage outflows into rivers cause eutrophication, impacting fish populations.

Oil Platform. © Shutterstock

P – Pressures

Pressures on marine fish

Human activities translate into several pressures that act on marine fish in different ways across all OSPAR areas. (Human Activities Thematic Assessment).

Fish and shellfish harvesting activities are responsible for the highest pressure on marine fish, mostly through increased mortality in wild animals (either as target or by-catch). Pollution is the second highest pressure, with substances being introduced to the marine habitats that fish directly depend upon, from a variety of sources like shipping, cities and industrial activities, transport on land and waste treatment and disposal. The same activities are also responsible for putting pressure on marine fish through other mechanisms such as the direct input of litter and microbial pathogens.

Summary of human activities and relative pressures on fish by ecoregion:

1. **Arctic Waters (Region I)**: Traditionally, fewer human activities are present in this area, given the relatively scarce human settlements. Nevertheless, pressures have been identified, mainly from sub-Arctic and temperate regions, the main ones being marine litter and the introduction of non-indigenous species, contaminating compounds and underwater noise.
2. **Greater North Sea (Region II)**: The main pressures acting on fish are selective extraction of species due to fishing, and physical loss or disturbance of substrate, mainly due to fishing activity (trawling

and dredging) but also to the offshore infrastructure needed for renewable energy and navigational dredging.

3. **Celtic Seas (Region III)**: In this area, the main pressures on fish arise from fishing (selective extraction of species, including by-catch), followed by inputs of contaminants (other substances) and marine litter.
4. **Bay of Biscay and Iberian Coast (Region IV)**: Selective extraction of species due to commercial fishing (and to a lesser extent due to tourism and recreational fisheries) is the main pressure in this area.
5. **Wider Atlantic (Region V)**: Given the low proximity of this area to coastal and shelf areas (the only inhabited area here is the Azores) where human activities are concentrated, the Wider Atlantic is mostly impacted by the selective extraction of species due to commercial fisheries and, to a lesser extent, by the input of marine litter and other substances from shipping and military operations.

Confidence Assessment:

OSPAR Region	Arctic Waters (Region I)	Greater North Sea (Region II)	Celtic Seas (Region III)	Bay of Biscay and Iberian Coast (Region IV)	OSPAR Maritime Area (Deep-sea fish)
Confidence	Low	High	High	High	Low

Fishing boats in Lekeitio, Spain. © Shutterstock

The anthropogenic pressures that affect fish are:

Extraction of, or mortality/injury to, wild species (by commercial and recreational fishing and other activities) [Biological]: The impact of fishing mortality among target fish and shellfish species can cause reduced prey availability in other fish species, multi-level trophic cascades and phenotypic changes in the life history traits of fished populations, and also affect food web dynamics – which may or may not be sustainable – predator-prey relationships and competitive interactions within fish communities (Jennings and Kaiser, 1998; Thrush and Dayton, 2010; Woods *et al*., 2016). The mortality associated with fishing (a size-selective activity) restricts the age structure of fish communities, reducing the proportion of older and larger individuals (Bosch *et al*., 2022). The body size of fish thus decreases due to overfishing, and this affects the size composition of the fish community (OSPAR, 2017h). Ecosystem-based Fisheries Management (EBFM) can be enhanced to mitigate such impacts.

Selective extraction of species, including non-target catches [Biological]: Fish and shellfish harvesting, either at professional or recreational level, can result in varying proportions of non-target fish by-catch. If the exploitation rates are unsustainable, this will have a negative impact on target and/or by-catch species. By-catch can refer to species of conservation concern like sharks, rays and skates, or to commercial species. The discarding of unwanted fish can lead to changes in species diversity, abundance and community structure (Jennings and Kaiser, 1998).

Physical disturbance to seabed (temporary or reversible) [Physical]: Altering habitat structure can result in loss of habitat, and changes in fish and benthic species diversity, community composition, biomass, growth and productivity, thus potentially reducing available prey and affecting fish survival (Jennings and Kaiser, 1998; Watling and Norse, 1998; Thrush and Dayton 2002; Gill, 2005; Hiddink *et al*., 2006; Thrush and Dayton 2010; Woods *et al*., 2016; Gasparatos *et al*., 2017). Trawl fisheries, dredging, coastal and offshore infrastructure modify the seabed morphology and may lead to the re-suspension of sediments. Re-suspension and subsequent disposition of sediments in other areas can increase turbidity, inhibiting the settlement and growth of benthic species and thus altering prey availability (Jennings and Kaiser, 1998; Gasparatos *et al*., 2017).

Physical loss (to land or marine habitat) [Physical]: Loss of habitat, particularly from fishing (Jennings and Kaiser, 1998; Woods *et al*., 2016), coastal and offshore developments (Gill, 2005; Gasparatos *et al*., 2017) and aquaculture (Naylor *et al*., 2000) can of course have a negative impact on fish and their prey. Such impact can be particularly important in the short and long term in areas that are routinely used by fish for spawning, feeding and as a nursery ground (see *Disturbances of species* below).

Changes to hydrological conditions [Physical]: Hydropower infrastructure can alter water flow regimes, thereby affecting the migration routes of diadromous fish species to spawning grounds and can trigger complex community changes that differ upstream and downstream owing to varying effects on flow regimes (Gasparatos *et al*., 2017). Change of freshwater input linked to climate change or the presence of man-made structures in rivers can alter local coastal hydrogeological conditions, increasing salinity and stratification (Barange and Perry, 2009), which are important local conditions to which many fish species have become adapted.

Disturbance of species (e.g. where they breed, rest and feed) due to human presence [Biological]: Disturbance leads to (temporary) habitat loss and higher energy expenditure (avoidance), with consequences for survival and reproduction in fish species (van Overzee and Rijnsdorp, 2014; Hawkins and Popper, 2017). Disruption of migration pathways and of access to breeding grounds for diadromous species can occur due to modification of watercourses (Gasparatos *et al*., 2017). The human activities that disturb fish species, due to their presence, are:

- coastal development involving the physical restructuring of rivers, coastline or seabed (water management), tourism and leisure infrastructure and nuclear energy;
- offshore construction for the production of energy (with offshore wind farms occupying a large surface area);
- ship traffic in any form (including fisheries);
- tourism and leisure activities (e.g., recreational boating at sea, sailing, recreational fishing, snorkelling, diving).

Input or spread of non-indigenous species [Biological]: Invasive species may be dispersed and introduced into new marine environments through international shipping, fishing, aquaculture, the aquarium trade and canal construction / operation (Woods *et al*., 2016). Invasive species can affect food web dynamics, displace native species, introduce diseases and lead to changes in habitat type, thereby significantly altering marine ecosystems (Crain *et al*., 2009; Gestoso *et al*., 2018). The pressure exerted is assessed in more detail in the Non-indigenous Species Thematic Assessment.

Input of microbial pathogens [Biological]: The anthropogenic activities that can facilitate the pathogenic invasions that can deplete wild fish stocks include aquaculture (including shrimp and salmon farming) (Naylor *et al*., 2000), invasive species (Crain *et al*., 2009) and marine litter (Amaral-Zettler *et al*., 2020).

Input of nutrients - diffuse sources, point sources, atmospheric deposition [Substances, litter and energy]: At local scale, inputs of nutrients from farming run-off, dredging, aquaculture and sewage releases can have negative impacts on fish species by causing eutrophication (Naylor *et al*., 2000). The installation and decommissioning of offshore energy developments can also cause contaminant remobilisation (Gill, 2005; Gasparatos *et al*., 2017). Eutrophication-induced hypoxia (oxygen depletion) can have detrimental effects, particularly on benthic fauna (lethal or sub-lethal) and bottom-dwelling fish (Crain *et al*., 2009; Woods *et al*., 2016). The negative impacts can include reduced benthic diversity and altered species composition, as well as changes to growth and reproduction, physiological stress and changes to migration patterns in mobile species.

Input of litter (solid waste matter, including micro-sized litter) [Substances, litter and energy]: The introduction of litter, whether land-based (rivers, industrial sources, tourism) or marine-based (shipping, fishing, aquaculture, tourism) can cause ingestion and entanglement, leading to reduced food consumption or predator avoidance, injury, suffocation or death (Woods *et al*., 2016). Input of litter into the environment can also facilitate the introduction of non-native species, diseases or toxic substances that can negatively impact fish species.

The input of litter and the consequent pressure on fish is linked with environmental impacts in the Marine Litter Thematic Assessment.

Input of other substances (e.g., synthetic substances, non-synthetic substances, radionuclides) - diffuse sources, point sources, atmospheric deposition, acute events [Substances, litter and energy]: Synthetic substances, non-synthetic substances and radionuclides can cause physical harm to fish. Fish populations in freshwater environments suffer the most acute threat of chemical contamination, for example local population extinction through metal contamination resulting from industrial or mining activities (Hamilton *et al*., 2016). In the marine environment, chemical contamination is a threat in coastal fisheries where pollutant levels are highest, particularly from oil run-off, production and transportation; petroleum; heavy metal contamination; and synthetic substances from agriculture and urbanisation (e.g., pharmaceuticals in sewage) (Hamilton *et al*., 2016). Food-chain transfer and bioaccumulation of pollutants in fish tissues (e.g., metals, persistent organic pollutants and organochlorine contaminants) can adversely affect fish in all aquatic environments, impacting reproduction, development and/or survival of offspring and causing population decline (Hamilton *et al*., 2016).

Inputs of other substances and their pressures on fish species are closely linked with environmental impacts in the Radioactive Substances Thematic Assessment and the Hazardous Substances Thematic Assessment.

Input of anthropogenic sound (impulsive, continuous) [Substances, litter and energy]: The activities that emit anthropogenic noise into the environment are shipping, military operations and construction. Anthropogenic noise is a form of energy that can result in behavioural impacts, physical and/or physiological impacts, masking and death (Gill, 2005). The behavioural impacts can be displacement and changes in swimming patterns and migration; these can affect fitness, survival and reproductive success. Masking due to anthropogenic noise makes it difficult to detect biologically important sounds, which can result in reduced survival for fish species. The physical and/or physiological impacts are temporal threshold shift (TTS) or permanent threshold shift (PTS) (Hawkins and Popper, 2017).

Inputs of noise and their pressures on fish are linked with the environmental impacts in the Underwater Noise Thematic Assessment.

Input of other forms of energy (including electromagnetic fields, light and heat) [Substances, litter and energy]: Offshore renewable energy operations emit electromagnetic fields (EM) into the environment that can have behavioural impacts (attraction/avoidance) on EM field-sensitive species (particularly elasmobranchs) (Gill, 2005; Gasparatos *et al*., 2017). These behavioural impacts can include displacement and changes in swimming patterns and migration, which in turn affect fitness, survival and reproductive success. The increase in average ocean temperatures driven by greenhouse gas-induced climate change can alter growth, reproduction, behaviour, migration patterns, spatial abundance and distribution, with the potential to cause community-level changes (Woods *et al*., 2016).

Changes in temperature caused by climate change and the pressure on fish are linked with the Climate Change Thematic Assessment.

Input of water - point sources (e.g., brine) [Substances, litter and energy]: Input of brine can occur as a by-product of industry (e.g., oil and gas extraction, chemical plant waste, desalination, irrigation run-off) and changes to salinity regimes can result from altered tidal exchange, drainage alterations, freshwater diversions, and global warming. Estuaries are particularly vulnerable to changes in salinity owing to slow water movement and close proximity to the drivers affecting salinity. Salinity changes can result in mortality or sub-lethal stress in fish and other benthic species and potentially lead to changes in community and ecosystem structure (Crain *et al*., 2009; Gasparatos *et al*., 2017), and can also have an important influence on the development and growth of many fish species (e.g., egg fertilization and incubation, yolk sac resorption, early embryogenesis, swim bladder inflation and larval growth) (Boeuf and Payan, 2001).

S – State

Population status of marine fish

OSPAR directly or indirectly assessed the population status of 316 marine fish across coastal, demersal, pelagic and deep-sea groups. This assessment was conducted by integrating commercially exploited marine fish stocks and sensitive species of conservation concern. None of the fish groups in any of the regions assessed was found to be in good environmental status. Arctic Waters (Region I) and Wider Atlantic (Region V) were not assessed. In addition, the status of fish listed by OSPAR as threatened and/or declining was assessed where possible; with some exceptions, these were found to have remained in poor status. Many of the fish are of unknown status. This refers to stocks for which assessments were attempted but for which definitive results were not available. Further work is required to improve the assessment of these stocks.

Arctic Waters Norwegian Sea	Greater North Sea	Celtic Seas	Bay of Biscay and Iberian Coast	OSPAR Maritime Area (Deep-sea fish)
Not fully assessed	Not in good environmental status	Not in good environmental status	Not in good environmental status	Not fully assessed

Confidence assessment:

OSPAR Region	Arctic Waters (Region I)	Greater North Sea (Region II)	Celtic Seas (Region III)	Bay of Biscay and Iberian Coast (Region IV)	OSPAR Maritime Area (Deep-sea fish)
Confidence	Not assessed	Medium	Medium	Medium	Low

OSPAR acts as a coordination platform in the North-East Atlantic for the regional implementation of the EU Marine Strategy Framework Directive (MSFD) that aims to achieve a Good Environmental Status (GES) in European marine environments, as well as for the coordination of other national frameworks. The characteristics of GES are determined by the individual EU member states, based on criteria elements, threshold values and methodological standards set regionally or at EU level. Norwegian, Icelandic, United Kingdom, Greenlandic and Faroese marine areas are not covered by the MSFD.

The overall status of fish was assessed by integrating the OSPAR common indicator for the recovery of sensitive fish species with third-party assessments of commercial fish stocks produced by ICES and ICCAT. Results were obtained for Greater North Sea (**Table S.1**), Celtic Seas (**Table S.2**) and Bay of Biscay and Iberian Coast (**Table S.3**) and presented for the species groups of coastal fish, demersal shelf fish and pelagic shelf fish. For the deep-sea fish species group, results were expressed for the OSPAR Maritime Area (**Table S.4**). Good environmental status was not achieved in any of the Regions, nor for any of the fish species groups (**Figure S.1**).

The integration method is described in the CEMP Guideline for fish thematic assessment. The overall status of fish in each species group was assessed with reference to a threshold which 80% of assessed items (defined as stocks and/or species) were required to achieve in order for the species group to be considered in good status. This includes those items for which status was unknown.

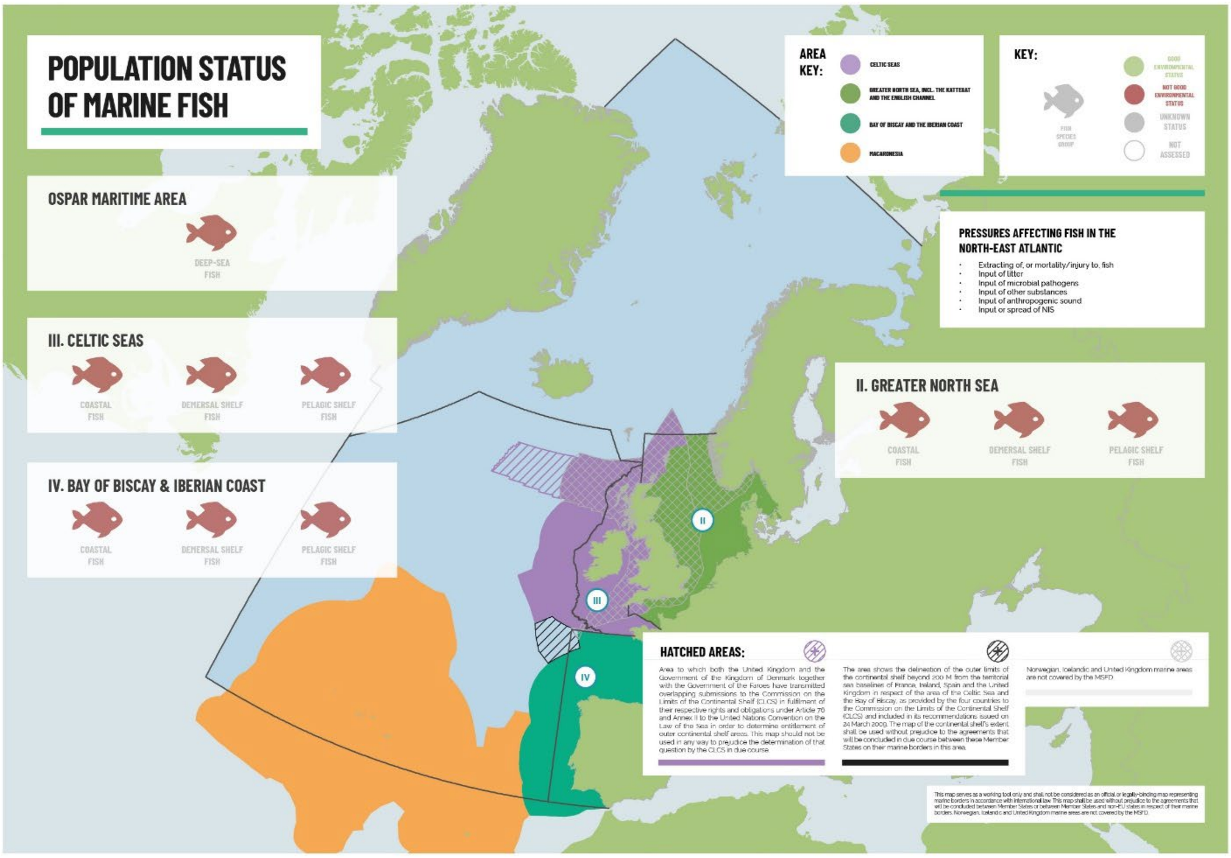


Figure S.1: Schematic representation of good environmental status of fish by species group and spatial assessment unit, based on the integrated fish assessment. Norwegian, Icelandic and United Kingdom marine areas are not covered by the MSFD.

The integrated assessment of fish covered 316 items, including 127 sensitive species (from Common Indicator FC1) and 189 commercial stocks from third-party assessments conducted by ICES and ICCAT, details of which can be found in the CEMP Guideline .

In the Greater North Sea area, 119 items were assessed comprising 37 sensitive species and 82 commercial stocks (**Table S.1**). In Celtic Seas, 121 items were assessed comprising 38 sensitive species and 83 commercial stocks (**Table S.3**). In Bay of Biscay and Iberian Coast, 91 items were assessed comprising 36 sensitive species and 55 commercial stocks (**Table S.3**). The 36 items assessed for deep-sea fish across the OSPAR Maritime Area (**Table S.4**) consisted of 12 sensitive species and 24 commercial stocks.

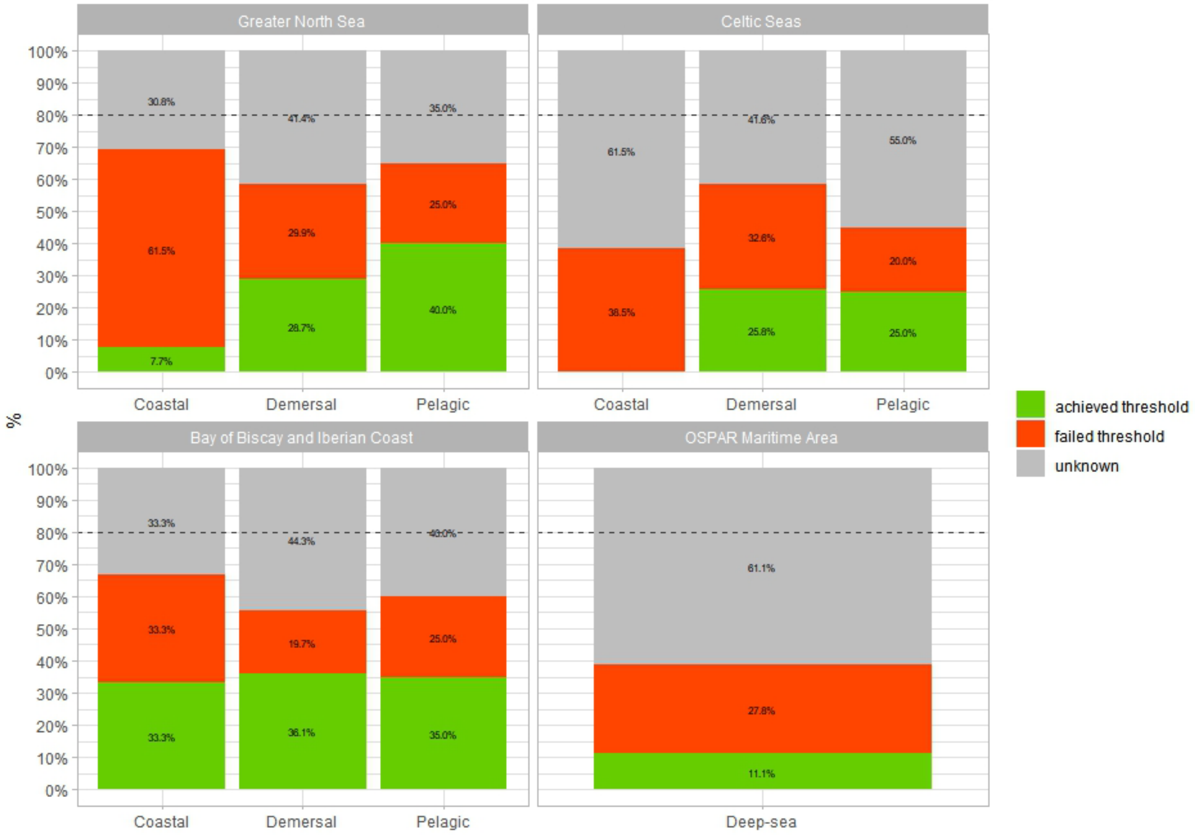


Figure S.2: Proportion of fish having achieved or failed the threshold for each species group and spatial assessment unit. To achieve good environmental status for the integrated status assessment of fish species groups, 80% of the items per group must have achieved their threshold. Assessment reference period 2015-2020.

Coastal fish:

Coastal fish are defined as fish which spend most of their life cycles in coastal or transitional waters, but they also include diadromous fish (e.g., Atlantic salmon, which straddles marine and fresh waters), whose movements may be much wider.

In the Greater North Sea, 13 coastal fish were assessed including nine sensitive species and four commercial stocks. Of these, one achieved the indicator threshold, eight failed the threshold and four were unknown (**Figure S.2**). Of the commercially exploited coastal fish stocks, none achieved the indicator threshold, indicating that none are being harvested at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive coastal fish species, one achieved the indicator threshold, indicating that recovery was taking place. Overall, for coastal fish in the Greater North Sea, good environmental status was not achieved.

In the Celtic Seas, 13 coastal fish were assessed including 10 sensitive species and three commercial stocks. Of these coastal fish, none achieved the threshold, five failed the threshold and eight were unknown (**Figure S.2**). Of the commercially exploited coastal fish stocks, none achieved the threshold, indicating that none are being harvested at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive coastal fish species, none achieved the threshold, indicating that recovery is taking place in none of the species. Overall, for coastal fish in the Celtic Seas, good environmental status was not achieved.

In the Bay of Biscay and Iberian Coast, nine items were assessed including six sensitive species and six commercial stocks. Of these, three achieved the threshold, three failed the threshold and three were unknown (**Figure S.2**). Of the commercially exploited coastal fish stocks, none achieved the threshold, indicating that none is being harvested at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive coastal fish species, three achieved the threshold, indicating that recovery was taking place for these three species. Overall, for coastal fish in the Bay of Biscay and Iberian Coast, good environmental status was not achieved.

The assessments of coastal fish covered items for which assesments were available. The assessments may thus not be representative of all coastal fish in the areas assessed. It should be noted that diadromous species (shads, lampreys, salmonids and European eel) are considered under coastal fish.

Deep-sea fish:

In the OSPAR Maritime Area, 36 deep-sea fish were assessed including 12 sensitive species and 24 commercial stocks. Of these, four achieved the threshold, 10 failed the threshold and 22 were unknown (**Figure S.2**). Of the commercially exploited deep-sea fish stocks, one achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive deep-sea fish species, three achieved the threshold, indicating that recovery was taking place for these species. Overall, for deep-sea fish in the OSPAR Maritime Area, good environmental status was not achieved.

The assessments of deep-sea fish covered items for which assesments were already available, and areas where there were enough data to use the common indicator. The assessments may thus not be representative of deep-sea fish in the OSPAR Maritime Area.

Pelagic shelf fish:

In the Greater North Sea, 20 pelagic shelf fish were assessed including two sensitive species and 18 commercial stocks. Of these, eight achieved the threshold, five failed the threshold, and seven were unknown (**Figure S.2**). Of the commercially exploited pelagic fish stocks, seven achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive pelagic fish species, one achieved the threshold, indicating that recovery was taking place for that species. Overall, for pelagic shelf fish in the Greater North Sea, good environmental status was not achieved.

In the Celtic Seas, 20 pelagic shelf fish were assessed including two sensitive species and 18 commercial stocks. Of these, five achieved the threshold, four failed the threshold, and 11 were unknown (**Figure S.2**). Of the commercially exploited pelagic fish stocks, five achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive pelagic shelf fish species, none achieved the threshold, indicating that recovery was not taking place for any of these species. Overall, for pelagic shelf fish in the Celtic Seas, good environmental status was not achieved.

In the Bay of Biscay and Iberian Coast, 20 pelagic shelf fish were assessed including three sensitive species and 17 commercial stocks. Of these, seven fish achieved the threshold, five failed the threshold and eight were unknown (**Figure S.2**). Of the commercially exploited pelagic fish stocks, six achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive pelagic fish species, one achieved the threshold, indicating that recovery was taking place for that species. Overall, for pelagic shelf fish in the Bay of Biscay and Iberian Coast, good environmental status was not achieved.

Demersal shelf fish:

In the Greater North Sea, 86 demersal shelf fish were assessed including 26 sensitive species and 60 commercial stocks. Of these, 25 fish achieved the threshold, 26 failed the threshold and 35 were unknown (**Figure S.2**). Of the commercially exploited demersal fish stocks, 13 achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive demersal fish species, 12 achieved the threshold, indicating that long term recovery was taking place for these species. Overall, for demersal shelf fish in the Greater North Sea, good environmental status was not achieved.

In the Celtic Seas, 88 demersal shelf fish were assessed including 26 sensitive species and 62 commercial stocks. Of these, 23 achieved the threshold, 29 failed the threshold and 36 were unknown (**Figure S.2**). Of the commercially exploited demersal fish stocks, 10 achieved the threshold, indicating harvesting at levels of mortality which can produce maximum sustainable yield and at the biomass levels capable of producing maximum sustainable yield. Of the sensitive demersal fish species, 13 achieved the threshold, indicating that recovery was taking place for those species. Overall, for demersal shelf fish in the Celtic Seas, good environmental status was not achieved.

In the Bay of Biscay and Iberian Coast, 62 demersal shelf fish were assessed including 27 sensitive species and 35 commercial stocks. Of these, 22 achieved the threshold, 12 failed the threshold and 28 were unknown (**Figure S.2**). Of the commercially exploited demersal fish stocks, eight achieved the threshold, indicating levels of mortality which can produce maximum sustainable yield and at biomass levels capable of producing maximum sustainable yield. Of the sensitive demersal fish species, 14 achieved the threshold, indicating that recovery was taking place. Overall, for demersal shelf fish in the Bay of Biscay and Iberian Coast, good environmental status was not achieved.

Table S.1: Results of the integrated assessment for fish in the Greater North Sea Region. Assessment reference period 2015-2020

Stock (if relevant)	Scientific name	Species	Type	Group	Threshold
bss.27.4bc7ad-h	*Dicentrarchus labrax*	European seabass	commercial	Coastal	failed
bss.27.6a7bj	*Dicentrarchus labrax*	European seabass	commercial	Coastal	unknown
pol.27.3a4	*Pollachius pollachius*	Pollack	commercial	Coastal	unknown
pol.27.67	*Pollachius pollachius*	Pollack	commercial	Coastal	unknown
	Raja undulata	Undulate ray	sensitive	Coastal	achieved
	Alosa spp	Shads n.e.i.	sensitive	Coastal	failed
	Anguilla anguilla	European eel	sensitive	Coastal	failed
	Cyclopterus lumpus	Lumpfish	sensitive	Coastal	failed
	Lampetra fluviatilis	River lamprey	sensitive	Coastal	failed
	Petromyzon marinus	Sea lamprey	sensitive	Coastal	failed
	Pollachius pollachius	Pollack	sensitive	Coastal	failed
	Zoarces viviparus	Viviparous eelpout	sensitive	Coastal	failed

	Salmo trutta trutta	Sea trout	sensitive	Coastal	unknown
lez.27.4a6a	*Lepidorhombus spp.*	Megrims nei	commercial	Demersal	achieved
dab.27.3a4	*Limanda limanda*	Common dab	commercial	Demersal	achieved
ank.27.78abd	*Lophius budegassa*	Blackbellied angler	commercial	Demersal	achieved
mon.27.78abd	*Lophius piscatorius*	Angler(=Monk)	commercial	Demersal	achieved
whg.27.47d	*Merlangius merlangus*	Whiting	commercial	Demersal	achieved
hke.27.3a46-8abd	*Merluccius merluccius*	European hake	commercial	Demersal	achieved
lem.27.3a47d	*Microstomus kitt*	Lemon sole	commercial	Demersal	achieved
ple.27.420	*Pleuronectes platessa*	European plaice	commercial	Demersal	achieved
rju.27.7de	*Raja undulata*	Undulate ray	commercial	Demersal	achieved
tur.27.3a	*Scophthalmus maximus*	Turbot	commercial	Demersal	achieved
tur.27.4	*Scophthalmus maximus*	Turbot	commercial	Demersal	achieved
sol.27.7e	*Solea solea*	Common sole	commercial	Demersal	achieved
nop.27.3a4	*Trisopterus esmarkii*	Norway pout	commercial	Demersal	achieved
cod.27.47d20	*Gadus morhua*	Atlantic cod	commercial	Demersal	failed
cod.27.7e-k	*Gadus morhua*	Atlantic cod	commercial	Demersal	failed
wit.27.3a47d	*Glyptocephalus cynoglossus*	Witch flounder	commercial	Demersal	failed
meg.27.7b-k8abd	*Lepidorhombus whiffiagonis*	Megrim	commercial	Demersal	failed
had.27.46a20	*Melanogrammus aeglefinus*	Haddock	commercial	Demersal	failed
had.27.7b-k	*Melanogrammus aeglefinus*	Haddock	commercial	Demersal	failed
whg.27.7b-ce-k	*Merlangius merlangus*	Whiting	commercial	Demersal	failed
ple.27.21-23	*Pleuronectes platessa*	European plaice	commercial	Demersal	failed
ple.27.7d	*Pleuronectes platessa*	European plaice	commercial	Demersal	failed
pok.27.3a46	*Pollachius virens*	Saithe(=Pollock)	commercial	Demersal	failed
sol.27.20-24	*Solea solea*	Common sole	commercial	Demersal	failed
sol.27.4	*Solea solea*	Common sole	commercial	Demersal	failed
sol.27.7d	*Solea solea*	Common sole	commercial	Demersal	failed
dgs.27.nea	*Squalus acanthias*	Spurdog	commercial	Demersal	failed
rjr.27.23a4	*Amblyraja radiata*	Starry ray	commercial	Demersal	unknown
gur.27.3-8	*Chelidonichthys cuculus*	Red gurnard	commercial	Demersal	unknown
rjb.27.3a4	*Dipturus spp*	common skate	commercial	Demersal	unknown
gug.27.3a47d	*Eutrigla gurnardus*	Grey gurnard	commercial	Demersal	unknown
cod.27.21	*Gadus morhua*	Atlantic cod	commercial	Demersal	unknown
gag.27.nea	*Galeorhinus galeus*	Tope shark	commercial	Demersal	unknown
ldb.27.7b-k8abd	*Lepidorhombus boscii*	Four-spot megrim	commercial	Demersal	unknown
rjf.27.67	*Leucoraja fullonica*	Shagreen ray	commercial	Demersal	unknown
rjn.27.3a4	*Leucoraja naevus*	Cuckoo ray	commercial	Demersal	unknown
anf.27.3a46	*Lophius budegassa, Lophius piscatorius*	Anglerfish nei	commercial	Demersal	unknown
whg.27.3a	*Merlangius merlangus*	Whiting	commercial	Demersal	unknown
mur.27.3a47d	*Mullus surmuletus*	striped red mullet	commercial	Demersal	unknown
mur.27.67a-ce-k89a	*Mullus surmuletus*	striped red mullet	commercial	Demersal	unknown
sdv.27.nea	*Mustelus asterias*	Smooth-hounds nei	commercial	Demersal	unknown
gfb.27.nea	*Phycis blennoides*	Greater forkbeard	commercial	Demersal	unknown
fle.27.3a4	*Platichthys flesus*	European flounder	commercial	Demersal	unknown
ple.27.7bc	*Pleuronectes platessa*	European plaice	commercial	Demersal	unknown
ple.27.7e	*Pleuronectes platessa*	European plaice	commercial	Demersal	unknown
rjh.27.4a6	*Raja brachyura*	Blonde ray	commercial	Demersal	unknown
rjh.27.7afg	*Raja brachyura*	Blonde ray	commercial	Demersal	unknown
rjc.27.3a47d	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
rjc.27.7e	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
rje.27.7fg	*Raja microocellata*	Small-eyed ray	commercial	Demersal	unknown
rjm.27.3a47d	*Raja montagui*	spotted ray	commercial	Demersal	unknown
rjm.27.67bj	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
rjm.27.7ae-h	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
raj.27.3a47d	*Rajidae n.e.i.*	Rays and skates nei	commercial	Demersal	unknown
raj.27.67a-ce-k	*Rajidae n.e.i.*	Rays and skates nei	commercial	Demersal	unknown
bll.27.3a47de	*Scophthalmus rhombus*	Brill	commercial	Demersal	unknown

bll.27.3a47de	*Scophthalmus rhombus*	Brill	commercial	Demersal	unknown
syc.27.3a47d	*Scyliorhinus canicula*	Small-spotted catshark	commercial	Demersal	unknown
syc.27.67a-ce-j	*Scyliorhinus canicula*	Small-spotted catshark	commercial	Demersal	unknown
syt.27.67	*Scyliorhinus stellaris*	Nursehound	commercial	Demersal	unknown
sol.27.7bc	*Solea solea*	Common sole	commercial	Demersal	unknown
	Chelidonichthys lucerna	Tub gurnard	sensitive	Demersal	achieved
	Conger conger	Conger eel	sensitive	Demersal	achieved
	Helicolenus dactylopterus	Bluemouth	sensitive	Demersal	achieved
	Leucoraja naevus	Cuckoo ray	sensitive	Demersal	achieved
	Lophius budegassa	Blackbellied anglerfish	sensitive	Demersal	achieved
	Lophius piscatorius	Whitebellied anglerfish	sensitive	Demersal	achieved
	Mustelus spp	Smoothhounds n.e.i.	sensitive	Demersal	achieved
	Phycis blennoides	Greater forkbeard	sensitive	Demersal	achieved
	Raja brachyura	Blonde ray	sensitive	Demersal	achieved
	Raja clavata	Thornback ray	sensitive	Demersal	achieved
	Raja montagui	Spotted ray	sensitive	Demersal	achieved
	Scyliorhinus canicula	Lesser spotted dogfish	sensitive	Demersal	achieved
	Amblyraja radiata	Starry ray	sensitive	Demersal	failed
	Anarhichas lupus	Atlantic wolffish	sensitive	Demersal	failed
	Dasyatis pastinaca	Common stingray	sensitive	Demersal	failed
	Galeorhinus galeus	Tope	sensitive	Demersal	failed
	Hippoglossus hippoglossus	Atlantic halibut	sensitive	Demersal	failed
	Lepidorhombus whiffiagonis	Megrim	sensitive	Demersal	failed
	Leucoraja circularis	Sandy ray	sensitive	Demersal	failed
	Leucoraja fullonica	Shagreen ray	sensitive	Demersal	failed
	Raja microocellata	Smalleyed ray	sensitive	Demersal	failed
	Scophthalmus rhombus	Brill	sensitive	Demersal	failed
	Scyliorhinus stellaris	Nursehound	sensitive	Demersal	failed
	Sebastes viviparus	Norway redfish	sensitive	Demersal	failed
	Dipturus oxyrinchus	Longnosed skate	sensitive	Demersal	unknown
	Sebastes spp	Redfish n.e.i.	sensitive	Demersal	unknown
san.sa.3r	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	achieved
san.sa.4	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	achieved
her.27.1-24a514a	*Clupea harengus*	Atlantic herring	commercial	Pelagic	achieved
her.27.3a47d	*Clupea harengus*	Atlantic herring	commercial	Pelagic	achieved
mac.27.nea	*Scomber scombrus*	Atlantic mackerel	commercial	Pelagic	achieved
spr.27.3a4	*Sprattus sprattus*	European sprat	commercial	Pelagic	achieved
spr.27.7de	*Sprattus sprattus*	European sprat	commercial	Pelagic	achieved
san.sa.1r	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	failed
san.sa.2r	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	failed
her.27.20-24	*Clupea harengus*	Atlantic herring	commercial	Pelagic	failed
whb.27.1-91214	*Micromesistius poutassou*	Blue whiting(=Poutassou)	commercial	Pelagic	failed
hom.27.2a4a5b6a7a-ce-k8	*Trachurus trachurus*	Atlantic horse mackerel	commercial	Pelagic	failed
san.sa.5r	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	unknown
san.sa.6	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	unknown
san.sa.7r	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	unknown
bsk.27.nea	*Cetorhinus maximus*	basking shark	commercial	pelagic	unknown
pil.27.7	*Sardina pilchardus*	European pilchard(=Sardine)	commercial	Pelagic	unknown

Table S.2: Results of the integrated assessment for fish in the Celtic Seas Region. Assessment reference period 2015-2020

Stock (if relevant)	Scientific name	Species	Type	Group	Threshold
bss.27.4bc7ad-h	*Dicentrarchus labrax*	European seabass	commercial	Coastal	failed
bss.27.6a7bj	*Dicentrarchus labrax*	European seabass	commercial	Coastal	unknown
pol.27.67	*Pollachius pollachius*	Pollack	commercial	Coastal	unknown
	Alosa spp	Shads n.e.i.	sensitive	Coastal	failed
	Cyclopterus lumpus	Lumpfish	sensitive	Coastal	failed
	Labrus bergylta	Ballan wrasse	sensitive	Coastal	failed
	Pollachius pollachius	Pollack	sensitive	Coastal	failed
	Anguilla anguilla	European eel	sensitive	Coastal	unknown
	Lampetra fluviatilis	River lamprey	sensitive	Coastal	unknown
	Petromyzon marinus	Sea lamprey	sensitive	Coastal	unknown
	Salmo trutta trutta	Sea trout	sensitive	Coastal	unknown
	Scorpaena scrofa	red scorpionfish	sensitive	Coastal	unknown
	Zoarces viviparus	Viviparous eelpout	sensitive	Coastal	unknown
lez.27.4a6a	*Lepidorhombus spp.*	Megrims nei	commercial	Demersal	achieved
ank.27.78abd	*Lophius budegassa*	Blackbellied angler	commercial	Demersal	achieved
mon.27.78abd	*Lophius piscatorius*	Angler(=Monk)	commercial	Demersal	achieved
had.27.7a	*Melanogrammus aeglefinus*	Haddock	commercial	Demersal	achieved
whg.27.47d	*Merlangius merlangus*	Whiting	commercial	Demersal	achieved
hke.27.3a46-8abd	*Merluccius merluccius*	European hake	commercial	Demersal	achieved
lem.27.3a47d	*Microstomus kitt*	Lemon sole	commercial	Demersal	achieved
ple.27.7a	*Pleuronectes platessa*	European plaice	commercial	Demersal	achieved
rju.27.7de	*Raja undulata*	Undulate ray	commercial	Demersal	achieved
tur.27.4	*Scophthalmus maximus*	Turbot	commercial	Demersal	achieved
cod.27.6a	*Gadus morhua*	Atlantic cod	commercial	Demersal	failed
cod.27.7a	*Gadus morhua*	Atlantic cod	commercial	Demersal	failed
cod.27.7e-k	*Gadus morhua*	Atlantic cod	commercial	Demersal	failed
wit.27.3a47d	*Glyptocephalus cynoglossus*	Witch flounder	commercial	Demersal	failed
meg.27.7b-k8abd	*Lepidorhombus whiffiagonis*	Megrim	commercial	Demersal	failed
had.27.46a20	*Melanogrammus aeglefinus*	Haddock	commercial	Demersal	failed
had.27.7b-k	*Melanogrammus aeglefinus*	Haddock	commercial	Demersal	failed
whg.27.6a	*Merlangius merlangus*	Whiting	commercial	Demersal	failed
whg.27.7a	*Merlangius merlangus*	Whiting	commercial	Demersal	failed
whg.27.7b-ce-k	*Merlangius merlangus*	Whiting	commercial	Demersal	failed
ple.27.7fg	*Pleuronectes platessa*	European plaice	commercial	Demersal	failed
ple.27.7h-k	*Pleuronectes platessa*	European plaice	commercial	Demersal	failed
pok.27.3a46	*Pollachius virens*	Saithe(=Pollock)	commercial	Demersal	failed
ghl.27.561214	*Reinhardtius hippoglossoides*	Greenland halibut	commercial	Demersal	failed
reg.27.561214	*Sebastes norvegicus*	Golden redfish	commercial	Demersal	failed
sol.27.7a	*Solea solea*	Common sole	commercial	Demersal	failed
sol.27.7fg	*Solea solea*	Common sole	commercial	Demersal	failed
dgs.27.nea	*Squalus acanthias*	Spurdog	commercial	Demersal	failed
rjr.27.23a4	*Amblyraja radiata*	Starry ray	commercial	Demersal	unknown
gur.27.3-8	*Chelidonichthys cuculus*	Red gurnard	commercial	Demersal	unknown
rjb.27.3a4	*Dipturus spp*	common skate	commercial	Demersal	unknown
rjb.27.67a-ce-k	*Dipturus spp*	common skate	commercial	Demersal	unknown
gug.27.3a47d	*Eutrigla gurnardus*	Grey gurnard	commercial	Demersal	unknown
gag.27.nea	*Galeorhinus galeus*	Tope shark	commercial	Demersal	unknown
ldb.27.7b-k8abd	*Lepidorhombus boscii*	Four-spot megrim	commercial	Demersal	unknown
rji.27.67	*Leucoraja circularis*	Sandy ray	commercial	Demersal	unknown

rjl.27.67	*Leucoraja circularis*	Sandy ray	commercial	Demersal	unknown
rjf.27.67	*Leucoraja fullonica*	Shagreen ray	commercial	Demersal	unknown
rjn.27.3a4	*Leucoraja naevus*	Cuckoo ray	commercial	Demersal	unknown
anf.27.3a46	*Lophius budegassa, Lophius piscatorius*	Anglerfish nei	commercial	Demersal	unknown
mur.27.67a-ce-k89a	*Mullus surmuletus*	striped red mullet	commercial	Demersal	unknown
sdv.27.nea	*Mustelus asterias*	Smooth-hounds nei	commercial	Demersal	unknown
gfb.27.nea	*Phycis blennoides*	Greater forkbeard	commercial	Demersal	unknown
ple.27.7bc	*Pleuronectes platessa*	European plaice	commercial	Demersal	unknown
rjh.27.4c7d	*Raja brachyura*	Blonde ray	commercial	Demersal	unknown
rjh.27.7afg	*Raja brachyura*	Blonde ray	commercial	Demersal	unknown
rjh.27.9a	*Raja brachyura*	Blonde ray	commercial	Demersal	unknown
rjc.27.6	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
rjc.27.7afg	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
rje.27.7de	*Raja microocellata*	Small-eyed ray	commercial	Demersal	unknown
rje.27.7fg	*Raja microocellata*	Small-eyed ray	commercial	Demersal	unknown
rjm.27.3a47d	*Raja montagui*	spotted ray	commercial	Demersal	unknown
rjm.27.67bj	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
rjm.27.7ae-h	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
rju.27.7bj	*Raja undulata*	Undulate ray	commercial	Demersal	unknown
raj.27.3a47d	*Rajidae n.e.i.*	Rays and skates nei	commercial	Demersal	unknown
raj.27.67a-ce-k	*Rajidae n.e.i.*	Rays and skates nei	commercial	Demersal	unknown
rja.27.nea	*Rostroraja alba*	White skate	commercial	Demersal	unknown
syc.27.67a-ce-j	*Scyliorhinus canicula*	Small-spotted catshark	commercial	Demersal	unknown
syt.27.67	*Scyliorhinus stellaris*	Nursehound	commercial	Demersal	unknown
sol.27.7bc	*Solea solea*	Common sole	commercial	Demersal	unknown
sol.27.7h-k	*Solea solea*	Common sole	commercial	Demersal	unknown
nop.27.6a	*Trisopterus esmarkii*	Norway pout	commercial	Demersal	unknown
	Conger conger	Conger eel	sensitive	Demersal	achieved
	Dipturus oxyrinchus	Longnosed skate	sensitive	Demersal	achieved
	Dipturus spp	Common skate complex	sensitive	Demersal	achieved
	Galeorhinus galeus	Tope	sensitive	Demersal	achieved
	Helicolenus dactylopterus	Bluemouth	sensitive	Demersal	achieved
	Leucoraja circularis	Sandy ray	sensitive	Demersal	achieved
	Leucoraja fullonica	Shagreen ray	sensitive	Demersal	achieved
	Mustelus spp	Smoothhounds n.e.i.	sensitive	Demersal	achieved
	Raja brachyura	Blonde ray	sensitive	Demersal	achieved
	Raja clavata	Thornback ray	sensitive	Demersal	achieved
	Raja montagui	Spotted ray	sensitive	Demersal	achieved
	Scyliorhinus canicula	Lesser spotted dogfish	sensitive	Demersal	achieved
	Scyliorhinus stellaris	Nursehound	sensitive	Demersal	achieved
	Anarhichas lupus	Atlantic wolffish	sensitive	Demersal	failed
	Chelidonichthys lucerna	Tub gurnard	sensitive	Demersal	failed
	Dasyatis pastinaca	Common stingray	sensitive	Demersal	failed
Rockall (6b) only	*Gadus morhua*	Atlantic cod	sensitive	Demersal	failed
	Molva macrophthalma	Spanish ling	sensitive	Demersal	failed
	Molva molva	Ling	sensitive	Demersal	failed
	Phycis blennoides	Greater forkbeard	sensitive	Demersal	failed
	Raja microocellata	Smalleyed ray	sensitive	Demersal	failed
	Scophthalmus maximus	Turbot	sensitive	Demersal	failed
	Scophthalmus rhombus	Brill	sensitive	Demersal	failed
	Sebastes viviparus	Norway redfish	sensitive	Demersal	failed
	Hippoglossus hippoglossus	Atlantic halibut	sensitive	Demersal	unknown
	Sebastes spp	Redfish n.e.i.	sensitive	Demersal	unknown
her.27.3a47d	*Clupea harengus*	Atlantic herring	commercial	Pelagic	achieved
her.27.nirs	*Clupea harengus*	Atlantic herring	commercial	Pelagic	achieved
BSH-North Atlantic	*Prionace glauca*	Blue shark	commercial	Pelagic	achieved
mac.27.nea	*Scomber scombrus*	Atlantic mackerel	commercial	Pelagic	achieved

mac.27.nea	*Scomber scombrus*	Atlantic mackerel	commercial	Pelagic	achieved
ALB-North Atlantic	*Thunnus alalunga*	Albacore	commercial	Pelagic	achieved
her.27.irls	*Clupea harengus*	Atlantic herring	commercial	Pelagic	failed
whb.27.1-91214	*Micromesistius poutassou*	Blue whiting(=Poutassou)	commercial	Pelagic	failed
hom.27.2a4a5b6a7a-ce-k8	*Trachurus trachurus*	Atlantic horse mackerel	commercial	Pelagic	failed
thr.27.nea	*Alopias spp*	Thresher sharks	commercial	Pelagic	unknown
san.27.6a	*Ammodytes spp*	Sandeels(=Sandlances) nei	commercial	Pelagic	unknown
boc.27.6-8	*Capros aper*	Boarfish	commercial	Pelagic	unknown
bsk.27.nea	*Cetorhinus maximus*	basking shark	commercial	pelagic	unknown
her.27.6aN	*Clupea harengus*	Atlantic herring	commercial	Pelagic	unknown
her.27.6aS7bc	*Clupea harengus*	Atlantic herring	commercial	Pelagic	unknown
pil.27.7	*Sardina pilchardus*	European pilchard(=Sardine)	commercial	Pelagic	unknown
spr.27.67a-cf-k	*Sprattus sprattus*	European sprat	commercial	Pelagic	unknown
agn.27.nea	*Squatina squatina*	Angel shark	commercial	Pelagic	unknown
BFT-E Atl/Med	*Thunnus thinnus*	Atlantic bluefin tuna	commercial	Pelagic	unknown
	Brama brama	Atlantic pomfret	sensitive	Pelagic	failed
	Mola mola	Ocean sunfish	sensitive	Pelagic	unknown

Table S.3: Results of the integrated assessment for fish in the Bay of Biscay and Iberian Coast Region. Assessment reference period 2015-2020

Stock (if relevant)	Scientific name	Species	Type	Group	Threshold
bss.27.8ab	*Dicentrarchus labrax*	European seabass	commercial	Coastal	failed
bss.27.8c9a	*Dicentrarchus labrax*	European seabass	commercial	Coastal	unknown
pol.27.89a	*Pollachius pollachius*	Pollack	commercial	Coastal	unknown
mon.27.78abd	*Lophius piscatorius*	Angler(=Monk)	commercial	Demersal	achieved
mon.27.8c9a	*Lophius piscatorius*	Angler(=Monk)	commercial	Demersal	achieved
ank.27.78abd	*Lophius budegassa*	Blackbellied angler	commercial	Demersal	achieved
ank.27.8c9a	*Lophius budegassa*	Blackbellied angler	commercial	Demersal	achieved
rjn.27.678abd	*Leucoraja naevus*	Cuckoo ray	commercial	Demersal	achieved
hke.27.3a46-8abd	*Merluccius merluccius*	European hake	commercial	Demersal	achieved
ldb.27.8c9a	*Lepidorhombus boscii*	Four-spot megrim	commercial	Demersal	achieved
meg.27.8c9a	*Lepidorhombus whiffiagonis*	Megrim	commercial	Demersal	achieved
sol.27.8ab	*Solea solea*	Common sole	commercial	Demersal	failed
hke.27.8c9a	*Merluccius merluccius*	European hake	commercial	Demersal	failed
meg.27.7b-k8abd	*Lepidorhombus whiffiagonis*	Megrim	commercial	Demersal	failed
dgs.27.nea	*Squalus acanthias*	Spurdog	commercial	Demersal	failed
rjc.27.8abd	*Raja clavata*	Thornback ray	commercial	Demersal	failed
rjb.27.89a	*Dipturus spp*	common skate	commercial	Demersal	unknown
sol.27.8c9a	*Solea solea*	Common sole	commercial	Demersal	unknown
rjn.27.8c	*Leucoraja naevus*	Cuckoo ray	commercial	Demersal	unknown
rjn.27.9a	*Leucoraja naevus*	Cuckoo ray	commercial	Demersal	unknown
ldb.27.7b-k8abd	*Lepidorhombus boscii*	Four-spot megrim	commercial	Demersal	unknown
gfb.27.nea	*Phycis blennoides*	Greater forkbeard	commercial	Demersal	unknown
raj.27.89a	*Rajidae n.e.i.*	Rays and skates nei	commercial	Demersal	unknown
gur.27.3-8	*Chelidonichthys cuculus*	Red gurnard	commercial	Demersal	unknown
syc.27.8abd	*Scyliorhinus canicula*	Small-spotted catshark	commercial	Demersal	unknown
syc.27.8c9a	*Scyliorhinus canicula*	Small-spotted catshark	commercial	Demersal	unknown
sdv.27.nea	*Mustelus asterias*	Smooth-hounds nei	commercial	Demersal	unknown
rjm.27.8	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
rjm.27.9a	*Raja montagui*	Spotted ray	commercial	Demersal	unknown
mur.27.67a-ce-k89a	*Mullus surmuletus*	striped red mullet	commercial	Demersal	unknown
rjc.27.8c	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
rjc27.9a	*Raja clavata*	Thornback ray	commercial	Demersal	unknown
gag.27.nea	*Galeorhinus galeus*	Tope shark	commercial	Demersal	unknown
rju.27.8ab	*Raja undulata*	Undulate ray	commercial	Demersal	unknown

rju.27.8ab	*Raja undulata*	Undulate ray	commercial	Demersal	unknown
rju.27.8c	*Raja undulata*	Undulate ray	commercial	Demersal	unknown
rju.27.9a	*Raja undulata*	Undulate ray	commercial	Demersal	unknown
rja.27.nea	*Rostroraja alba*	White skate	commercial	Demersal	unknown
whg.27.89a	*Merlangius merlangus*	Whiting	commercial	Demersal	unknown
ALB-North Atlantic	*Thunnus alalunga*	Albacore	commercial	Pelagic	achieved
hom.27.9a	*Trachurus trachurus*	Atlantic horse mackerel	commercial	Pelagic	achieved
mac.27.nea	*Scomber scombrus*	Atlantic mackerel	commercial	Pelagic	achieved
BSH-North Atlantic	*Prionace glauca*	Blue shark	commercial	Pelagic	achieved
ane.27.8	*Engraulis encrasicolus*	European anchovy	commercial	Pelagic	achieved
SKJ-East Atlantic	*Katsuwonus pelamis*	Skipjack tuna	commercial	Pelagic	achieved
hom.27.2a4a5b6a7a-ce-k8	*Trachurus trachurus*	Atlantic horse mackerel	commercial	Pelagic	failed
whb.27.1-91214	*Micromesistius poutassou*	Blue whiting(=Poutassou)	commercial	Pelagic	failed
pil.27.8abd	*Sardina pilchardus*	European pilchard(=Sardine)	commercial	Pelagic	failed
pil.27.8c9a	*Sardina pilchardus*	European pilchard(=Sardine)	commercial	Pelagic	failed
SMA-North Atlantic	*Isurus oxyrinchus*	Shortfin mako	commercial	Pelagic	failed
agn.27.nea	*Squatina squatina*	Angel shark	commercial	Pelagic	unknown
BFT-E Atl/Med	*Thunnus thinnus*	Atlantic bluefin tuna	commercial	Pelagic	unknown
bsk.27.nea	*Cetorhinus maximus*	basking shark	commercial	pelagic	unknown
boc.27.6-8	*Capros aper*	Boarfish	commercial	Pelagic	unknown
ane.27.9a	*Engraulis encrasicolus*	European anchovy	commercial	Pelagic	unknown
thr.27.nea	*Alopias spp*	Thresher sharks	commercial	Pelagic	unknown
	Scorpaena scrofa	red scorpionfish	sensitive	Coastal	achieved
	Alosa spp	Shads n.e.i.	sensitive	Coastal	achieved
	Raja undulata	Undulate ray	sensitive	Coastal	achieved
	Argyrosomus regius	Meagre	sensitive	Coastal	failed
	Pollachius pollachius	Pollack	sensitive	Coastal	failed
	Anguilla anguilla	European eel	sensitive	Coastal	unknown
	Helicolenus dactylopterus	Bluemouth	sensitive	Demersal	achieved
	Conger conger	Conger eel	sensitive	Demersal	achieved
	Leucoraja naevus	Cuckoo ray	sensitive	Demersal	achieved
	Phycis blennoides	Greater forkbeard	sensitive	Demersal	achieved
	Scyliorhinus canicula	Lesser spotted dogfish	sensitive	Demersal	achieved
	Dipturus oxyrinchus	Longnosed skate	sensitive	Demersal	achieved
	Torpedo marmorata	Marbled electric ray	sensitive	Demersal	achieved
	Leucoraja circularis	Sandy ray	sensitive	Demersal	achieved
	Leucoraja fullonica	Shagreen ray	sensitive	Demersal	achieved
	Mustelus spp	Smoothhounds n.e.i.	sensitive	Demersal	achieved
	Raja montagui	Spotted ray	sensitive	Demersal	achieved
	Raja clavata	Thornback ray	sensitive	Demersal	achieved
	Galeorhinus galeus	Tope	sensitive	Demersal	achieved
	Chelidonichthys lucerna	Tub gurnard	sensitive	Demersal	achieved
	Raja brachyura	Blonde ray	sensitive	Demersal	failed
	Scophthalmus rhombus	Brill	sensitive	Demersal	failed
	Dasyatis pastinaca	Common stingray	sensitive	Demersal	failed
	Molva molva	Ling	sensitive	Demersal	failed
	Molva macrophthalma	Spanish ling	sensitive	Demersal	failed
	Dicentrarchus punctatus	Spotted seabass	sensitive	Demersal	failed
	Scophthalmus maximus	Turbot	sensitive	Demersal	failed
	Tetronarce nobiliana	Atlantic torpedo	sensitive	Demersal	unknown
	Dipturus spp	Common skate complex	sensitive	Demersal	unknown
	Scyliorhinus stellaris	Nursehound	sensitive	Demersal	unknown
	Pollachius virens	Saithe	sensitive	Demersal	unknown
	Raja microocellata	Smalleyed ray	sensitive	Demersal	unknown
	Polyprion americanus	Wreckfish	sensitive	Demersal	unknown
	Sparus aurata	Gilt-head bream	sensitive	Pelagic	achieved
	Brama brama	Atlantic pomfret	sensitive	Pelagic	unknown

	Sparus aurata	Gilt-head bream	sensitive	Pelagic	achieved
	Brama brama	Atlantic pomfret	sensitive	Pelagic	unknown
	Pomatomus saltatrix	Bluefish	sensitive	Pelagic	unknown

Table S.4: Results of integrated assessment for deep-sea fish in the OSPAR Maritime Area. Assessment reference period 2015-2020

Stock (if relevant)	Scientific name	Species	Type	Group	Threshold
bli.27.5b67	*Molva dypterygia*	Blue ling	commercial	Deep-sea	achieved
aru.27.5b6a	*Argentina silus*	Greater argentine	commercial	Deep-sea	failed
bsf.27.nea	*Aphanopus carbo*	Black scabbardfish	commercial	Deep-sea	unknown
aru.27.123a4	*Argentina silus*	Greater argentine	commercial	Deep-sea	unknown
aru.27.6b7-1012	*Argentina silus*	Greater argentine	commercial	Deep-sea	unknown
alf.27.nea	*Beryx spp.*	Alfonsinos nei	commercial	Deep-sea	unknown
usk.27.12ac	*Brosme brosme*	tusk	commercial	Deep-sea	unknown
usk.27.3a45b6a7-912b	*Brosme brosme*	Tusk(=Cusk)	commercial	Deep-sea	unknown
usk.27.6b	*Brosme brosme*	Tusk(=Cusk)	commercial	Deep-sea	unknown
guq.27.nea	*Centrophorus squamosus*	Leafscale gulper shark	commercial	Deep-sea	unknown
cyo.27.nea	*Centroscymnus coelolepis*	Portuguese dogfish	commercial	Deep-sea	unknown
rng.27.1245a8914ab	*Coryphaenoides rupestris*	Roundnose grenadier	commercial	Deep-sea	unknown
rng.27.3a	*Coryphaenoides rupestris*	Roundnose grenadier	commercial	Deep-sea	unknown
rng.27.5a10b12ac14b	*Coryphaenoides rupestris*	Roundnose grenadier	commercial	Deep-sea	unknown
rng.27.5b6712b	*Coryphaenoides rupestris*	Roundnose grenadier	commercial	Deep-sea	unknown
sck.27.nea	*Dalatias licha*	Kitefin shark	commercial	Deep-sea	unknown
sho.27.67	*Galeus melastomus*	Blackmouth catshark	commercial	Deep-sea	unknown
sho.27.89a	*Galeus melastomus*	Blackmouth catshark	commercial	Deep-sea	unknown
ory.27.nea	*Hoplostethus atlanticus*	Orange roughy	commercial	Deep-sea	unknown
rhg.27.nea	*Macrourus berglax*	Roughhead grenadier	commercial	Deep-sea	unknown
sbr.27.10	*Pagellus bogaraveo*	Blackspot seabream	commercial	Deep-sea	unknown
sbr.27.6-8	*Pagellus bogaraveo*	Blackspot seabream	commercial	Deep-sea	unknown
sbr.27.9	*Pagellus bogaraveo*	Blackspot seabream	commercial	Deep-sea	unknown
tsu.27.nea	*Trachyrincus scabrus*	Roughsnout grenadier	commercial	Deep-sea	unknown
	Galeus spp.	Deepwater catsharks n.e.i.	sensitive	Deep-sea	achieved
	Scymnodon ringens	Knifetooth shark	sensitive	Deep-sea	achieved
	Synaphobranchus kaupii	Kaup's arrowtooth eel	sensitive	Deep-sea	achieved
	Chimaera monstrosa	Rabbitfish	sensitive	Deep-sea	failed
	Dalatias licha	Kitefin shark	sensitive	Deep-sea	failed
	Deania calcea	Birdbeak dogfish	sensitive	Deep-sea	failed
	Epigonus telescopus	Bigeye	sensitive	Deep-sea	failed
	Etmopterus spinax	Velvetbelly lanternshark	sensitive	Deep-sea	failed
	Hexanchus griseus	Sixgill shark	sensitive	Deep-sea	failed
	Hydrolagus mirabilis	Large-eyed rabbitfish	sensitive	Deep-sea	failed
	Mora moro	Mora	sensitive	Deep-sea	failed
	Trachyrincus scabrus	Roughsnout grenadier	sensitive	Deep-sea	failed

Assessment of fish in the Norwegian waters of OSPAR Arctic Waters (Region I)

In the Norwegian waters of OSPAR Arctic Waters (Region I), the state of commercial fish stocks was based on stock status for the reference year 2020 under the ICES fisheries overview for the Norwegian and Barents Seas (ICES, 2021a, b). A stock was judged to be in good status if it received a green infographic in column 11 of Table A.1 of the relevant ICES fisheries overview (ICES, 2022), referring to stock size in relation to reference point. It should be noted that this definition is not the same as that used in the integrated fish assessment for other regions. Other, non-assessed stocks were taken from Table A.2 of the fisheries overviews (Stocks of unknown status) (ICES, 2022). The threshold is based on the reference level of Maximum Sustainable Yield (MSY) or, if that is not possible to estimate, Precautionary Approach (PA). **Table S.5** shows the results by stock and by species group. A total of 23 stocks were assessed. In 2020, eight (35%) achieved the threshold, seven (30%) did not achieve the threshold and eight (35%) were unknown with respect to threshold.

Coastal fish:
Among the coastal fish in the Norwegian waters of OSPAR Region I, two stocks were assessed. Neither Southern Norwegian coastal cod, nor Northern Norwegian coastal cod, were in good status.

Deep-sea fish:
Among deep-sea fish, five stocks were assessed. One stock, Greenland halibut (sub-areas 1 and 2), was in good status. Three were of unknown status. These were the greater silver smelt (sub-areas 1, 2 and 4 and division 3.a), tusk (sub-areas 1 and 2) and the roundnose grenadier (sub-areas 1, 2, 4, 8 and 9, division 14.a, and sub-divisions 14.b.2 and 5.a.2). One was not in good status: blue ling (sub-areas 1, 2, 8, 9 and 12 and divisions 3.a and 4.a).

Pelagic fish:
Among pelagic fish in the Norwegian waters of OSPAR Region I, seven stocks were assessed. Three were in good status: Norwegian spring spawning herring (sub-areas 1, 2, 5 and divisions 4.a and 14.a), mackerel (sub-areas 1–8 and 14 and division 9.a) and blue whiting (sub-areas 1–9, 12 and 14). Two were not in good status: horse mackerel (sub-area 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a –c, and e-k) and capelin (sub-areas 1 and 2 excluding division 2.a west of 5A°W). Two stocks were of unknown status: porbeagle (North-East Atlantic) and basking shark (North-East Atlantic).

Demersal shelf fish:
Among demersal fish in the Norwegian waters of OSPAR Region I, nine stocks were assessed. Four were in good status: cod, haddock, beaked redfish and saithe (all in sub-areas 1 and 2). Two were not in good status: golden redfish (sub-areas 1 and 2) and spurdog (North-East Atlantic). Three stocks were unknown: ling (sub-areas 1 and 2), greater forkbeard (North-East Atlantic) and starry ray (sub-areas 2 and 4 and division 3.a).

Table S.5: Norwegian waters of OSPAR Arctic Waters (Region I). Status of commercial stocks for reference year 2020. The threshold is based on the reference level of Maximum Sustainable Yield (MSY) or, if that is not possible to estimate, Precautionary Approach (PA)

Fish group	Stock	Status	Basis
Coastal	Cod in sub-areas 1 and 2, north of 67°N, northern Norwegian coastal cod	not good	PA
	Cod in sub-area 2 between 62A°N and 67A°N, southern Norwegian coastal cod	not good	MSY
Deep-sea	Greater silver smelt in sub-areas 1, 2, and 4, and in division 3.a	unknown	N/A
	Blue ling in sub-areas 1, 2, 8, 9, and 12 and divisions 3.a and 4.a	not good	MSY
	Greenland halibut in sub-areas 1 and 2	good	PA
	Tusk in sub-areas 1 and 2	unknown	N/A
	Roundnose grenadier in sub-areas 1, 2, 4, 8, and 9, division 14.a and sub-divisions 14.b.2 and 5.a.2	unknown	N/A
Pelagic	Herring in sub-areas 1, 2 and 5 and divisions 4.a and 14.a, Norwegian spring spawning herring	good	MSY
	Mackerel in sub-areas 1–8 and 14 and division 9.a	good	MSY
	Horse mackerel in sub-area 8 and divisions 2.a, 4.a, 5.b, 6.a, 7.a –c, e-k	not good	MSY
	Blue whiting in sub-areas 1–9, 12 and 14	good	MSY
	Capelin in sub-areas 1 and 2, excluding division 2.a west of 5A°W	not good	PA
	Porbeagle in sub-areas 1–10, 12 and 14	unknown	N/A
	Basking shark in sub-areas 1-10, 12 and 14	unknown	N/A
Demersal	Cod in sub-areas 1 and 2	good	MSY
	Haddock in sub-areas 1 and 2	good	MSY
	Saithe in sub-areas 1 and 2	good	PA
	Ling in sub-areas 1 and 2	unknown	N/A
	Golden redfish in sub-areas 1 and 2	not good	PA
	Beaked redfish in sub-areas 1 and 2	good	MSY
	Greater forkbeard in sub-areas 1–10, 12 and 14	unknown	N/A
	Starry ray in sub-areas 2 and 4 and division 3.a	unknown	N/A
	Spurdog in sub-areas 1–10, 12 and 14	not good	MSY

Threatened and/or declining fish in the OSPAR Maritime Area

A summary of threatened and/or declining fish species recently assessed under the OSPAR protected species and habitats (POSH) process is provided below. However, this does not include blue fin tuna, orange roughy, cod or two species of seahorses which are on the OSPAR List of Threatened and/or Declining Species but have not yet been assessed.

Six taxa (thornback ray, spotted ray, European eel, common skate complex, *Alosa* spp. and sea lamprey) are also assessed by the OSPAR Common Indicator 'Recovery of sensitive fish species', which uses different methods from the status assessments for listed species. In general, there is good agreement between the assessments where additional information is provided by the common indicator for some species, although some differences are noted for the allis shad. Seahorses were not assessed in the common indicators, nor were they included in the thematic assessment integration due to concerns about the data quality for these cryptic species in some areas. However, indicative common indicator metric results are provided below.

Coastal fish:
There exists an OSPAR assessment of one threatened and declining coastal species, the European sturgeon. Its status is highly critical, however, and its increased abundance in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast (Regions II, III, IV) has been due to restocking programes. Full details of this assessment can be found in the OSPAR Overview assessment of implementation reporting, and a summary is provided in **Table S.6**.

Table S.6: Summary of status assessments of OSPAR listed coastal fish

POSH Assessment of Coastal Fish	Sturgeon		
Region	**II**	**III**	**IV**
Distribution: breeding	↔	↔	↔
Distribution: non-breeding	↑	↑	↔
Population size: breeding	↔	↔	↔
Population size: non-breeding	↑	↑	↑
Condition	↔	↔	↔
Previous OSPAR status assessment	●	○	●
Status (overall assessment)	poor	poor	poor

Regions where species occurs (○) and has been recognised by OSPAR to be threatened and/or declining (●)

↓ decreasing trend or deterioration of the criterion assessed
↑ increasing trend or improvement in the criterion assessed
←→ no change observed in the criterion assessed
? trend unknown in the criterion assessed

See: European or Common Sturgeon - Status Assessment 2020

For comparative purposes, the OSPAR assessments of threatened and declining diadromous species (allis shad, sea lamprey, Atlantic salmon and European eel) are also considered under coastal fish.

The status of Atlantic salmon is still poor in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast (Regions II, III, IV). Its range of distribution has remained stable for the past decade, but abundance and condition are decreasing in some areas. While historical key threats were increasingly affecting populations in the past, many efforts to alleviate their effects have been undertaken and the situation is mostly stable or improving, but other threats are emerging and expanding. Full details of this assessment can be found in OSPAR Status Assessment 2022 - Atlantic salmon.

The status of the European eel is still very poor in all OSPAR Regions where the species occurs, with glass eel recruitment, although stable since 2010, remaining at a very low level and no clear sign of an upturn. While the pressure of commercial fishing on the stock appears to be decreasing in the current assessment period (2010-2021), other pressures (dams, turbines, habitat loss, pollution, poaching, diseases and pathogens, climate change, etc.) still pose a significant threat to the species. Full details of this assessment can be found in OSPAR Status Assessment 2022 – European eel. The 'Recovery of sensitive fish species' Common Indicator assessment for the European eel gives an unknown result for Celtic Seas, Bay of Biscay and Iberian Coast, and Wider Atlantic (Regions III, IV, V). However, the metric indicates a long-term decline with stable state (i.e., no further decline) in the short term for the Greater North Sea (Region II).

The status of the allis shad is very poor in the OSPAR Maritime Area. Currently the most successful spawning rivers are located in France and Portugal, but in both cases these populations are threatened. Portugal is a stronghold for this species, particularly in the central and northern Mondego, Vouga and Minho river basins, where large populations still exist. There was a very abundant and well documented population in the Gironde Basin (south-west France), but since 2000 both juvenile and adult abundance has declined dramatically. During this current assessment period (2009-2021), threats to this species are becoming more significant, mainly due to the construction of dams, fishing in estuaries (e.g., the Gironde) or by-catch at sea. There is also growing concern about new threats (i.e., invasive species, climate change and predation). Full details of this assessment can be found in OSPAR Overview assessment of implementation reporting and a summary is provided in **Table S.7**. The 'Recovery of sensitive fish species' Common Indicator assesses the *Alosa* spp. in the offshore area only, and results are in general agreement with the status assessment for the Allis shad, indicating that the long-term target of recovery was not achieved in the Greater North Sea and Celtic Seas (Regions II, III). However, the common indicator metric finds the *Alosa* spp. to be recovering in the offshore area of the Bay of Biscay and Iberian Coast (Region IV), with additional signs of short-term recovery in the Greater North Sea (Region II).

The status of sea lamprey is still poor in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast (Regions I-IV). Physical obstacles to species migration and freshwater habitat loss are the key pressures for the assessed sea lamprey breeding populations. Dams, habitat loss and pollution, still pose a significant threat to the species. Full details of this assessment can be found in OSPAR Status Assessment 2022 – Allis shad. The 'Recovery of sensitive fish species' Common Indicator also assessed sea lamprey, with an unknown metric result for the Bay of Biscay and Iberian Coast (Region IV) and a stable outcome for the Greater North Sea (Region II).

Table S.7: Summary of status assessments of OSPAR listed diadromous fish

POSH assessments of diadromous fish	Allis shad			Sea lamprey				Eel				Salmon			
Region	II	III	IV	I	II	III	IV	I	II	III	IV	I	II	III	IV
Distribution	↔	↔	↓	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Population size	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↓	↓	↔
Condition	↔	↔	↔	↔	↔	↔	↔	?	?	?	?	↔	↔	↓	↔
Previous OSPAR status assessment	•	•	•	•	•	•	•	•	•	•	•	•	•	•	•
Status (overall assessment)	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor

Regions where species occurs (○) and has been recognised by OSPAR to be threatened and/or declining (●)

↓ decreasing trend or deterioration of the criterion assessed

↑ increasing trend or improvement in the criterion assessed

←→ no change observed in the criterion assessed

? trend unknown in the criterion assessed

See: Allis Shad – Status Assessment 2022, Sea Lamprey – Status Assessment 2022, European Eel – Status Assessment 2022, Atlantic Salmon – Status Assessment 2022

Two OSPAR listed seahorse species are yet to be assessed, and the indicative results for *Hippocampus* spp. using the 'Recovery of sensitive fish species' Common Indicator method are not included due to data quality concerns. The preliminary common indicator metric results indicate unknown status in the Celtic Seas (Region III), a stable outcome in the Bay of Biscay and Iberian Coast (Region IV) and recovery in the Greater North Sea (Region II). However, these results should be treated with caution due to concerns relating to the efficiency of trawl surveys in capturing and identifying these cryptic species and a lack of occurrences in reference periods, particularly in stronghold areas (i.e., English Channel surveys).

Deep-sea fish:

There are OSPAR assessments of three threatened and/or declining deep-sea fish: gulper shark, leafscale gulper shark and Portuguese dogfish. For gulper shark, fishing pressure, identified as its only threat in the last OSPAR assessment, has declined thanks to regulations adopted within and beyond national waters. However, the available data are insufficient to evaluate the current status of the population, and the species is known to exhibit life-history traits that make the recovery process slow. For both leafscale gulper shark and Portuguese dogfish, all the pressures identified in the last OSPAR assessment have declined, several fisheries regulations having been adopted within and beyond national waters. It is not possible to evaluate the current status of either species, though they are known to exhibit life-history traits that make the recovery process slow. Full details of these assessments can be found in OSPAR Status Assessment 2021 – Gulper shark, OSPAR Status Assessment 2021 – Leafscale gulper shark and OSPAR Status Assessment 2021 – Portuguese dogfish and a summary is provided in **Table S.8**.

Table S.8: Summary of status assessments of OSPAR listed deep-sea fish

POSH assessments of deep-sea fish	Gulper shark		Leafscale Gulper shark				Portugese dogfish			
Region	IV	V	I	III	IV	V	I	III	IV	V
Distribution	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔
Population size	?	?	↔	↔	↔	↔	↔	↔	↔	↔
Condition, Demographics	?	?	low	low	low	low	low	low	low	low
Previous OSPAR status assessment	•	•	•	•	•	•	•	•	•	•
Status (overall assessment)	?	?	?	poor	poor	poor	poor	poor	poor	poor

Regions where species occurs (○) and has been recognised by OSPAR to be threatened and/or declining (●)

↓ decreasing trend or deterioration of the criterion assessed

↑ increasing trend or improvement in the criterion assessed

←→ no change observed in the criterion assessed

? trend unknown in the criterion assessed

See: Gulper shark – Status Assessment 2021, Leafscale gulper shark – Status Assessment 2021, Portuguese dogfish – Status Assessment 2021

Pelagic shelf fish:

There are OSPAR assessments of two threatened and/or declining pelagic fish: basking shark and porbeagle. For basking shark, there is no evidence to suggest that its current status has changed as compared with the previous assessment, and its current population status is still unknown. Management and conservation measures have been developed, but international coordination of measures is still needed. Further details can be found in the OSPAR Status Assessment 2021 – Basking shark. Porbeagle is a prohibited species for commercial fishing under EU fishing regulations. The most recent ICES assessment in 2019 considers the status of its stocks to be unknown. The species' moderate intrinsic population growth rate qualified the porbeagle to be on the OSPAR List in 2008, since this rate allows only a slow recovery from depletion. This sensitivity to exploitation remains. Full details of this assessment can be found in OSPAR Status Assessment 2021 - Porbeagle and a summary is provided in **Table S.9**.

Table S.9: Summary of status assessments of OSPAR listed pelagic fish

POSH assessments of deep-sea fish	Basking shark					Porbeagle shark				
Region	I	II	III	IV	V	I	II	III	IV	V
Distribution	↔	←	↔	↔	↔	?	?	?	?	?
Population size	?	?	?	?	?	?	?	?	?	?
Condition, Demographics	?	?	?	?	?	?	?	?	?	?
Previous OSPAR status assessment	•	•	•	•	•	•	•	•	•	•
Status (overall assessment)	poor	poor	poor	poor	poor	?	?	?	?	?

Regions where species occurs (○) and has been recognised by OSPAR to be threatened and/or declining (●)

↓ decreasing trend or deterioration of the criterion assessed

↑ increasing trend or improvement in the criterion assessed

←→ no change observed in the criterion assessed

? trend unknown in the criterion assessed

See: Basking shark – Status Assessment 2021, Porbeagle – Status Assessment 2021

There are OSPAR assessments of five threatened and declining demersal shelf fish: spurdog, angel shark, common skate complex, spotted ray and thornback ray. Of these species, improved status is evidenced for spurdog, spotted ray and thornback ray.

Spurdog is a prohibited species for commercial fishing in EU, United Kingdom and Norwegian waters, with some exceptions for unavoidable by-catch. There are indications that its status is improving, and its recruitment appears to have improved over the last ten years. However, the stock of this species remains low compared with historical levels. Full details of this assessment can be found in OSPAR Status Assessment 2021 – Spurdog.

The angel shark remains a rare species that declined severely in the OSPAR Maritime Area and adjacent waters (e.g., the Mediterranean Sea) during the 20th century; it was lost from large parts of the OSPAR Area from the 1960s to the 1990s. Its low productivity and limited movements mean that any perceptible improvement in status would only occur over a decadal timeframe. This is still the case in the current assessment and, while there is no evidence of further deterioration, neither is there any sign of improving status. Full details of this assessment can be found in OSPAR Status Assessment 2021 – Angel shark.

For common skate complex, while there have been positive signs in the stocks of both species in parts of the Greater North Sea and Celtic Seas (Regions II, III) in terms of increasing catch rates as indicative measures of improvement, both species are still infrequently recorded or absent from some former parts of their geographic range. Both species in the common skate complex are on the prohibited list under EU fishing regulations. Full details of this assessment can be found in OSPAR Status Assessment 2021 – Common skate. The additional information provided by the 'Recovery of sensitive species' Common Indicator metric found that populations of the common skate complex (*Dipturus* spp.) were recovering in the Celtic Seas (Region III) and stable in the Wider Atlantic (Region V) (i.e., no further decline).

For spotted ray, ICES stock size indicators show an increasing trend within some OSPAR Regions where the species is assessed, with OSPAR Region II showing a more pronounced increase since 2009. For the Celtic Seas and Bay of Biscay and Iberian Coast (Regions III, IV), the indicative trend based on stock size is less clear, as there are comparatively wide confidence limits around the estimates and the increases indicated are more recent (i.e., over approximately the last decade). Like all elasmobranchs this species is vulnerable to fishing mortality. Full details of this assessment can be found in OSPAR Status Assessment 2021 – Spotted ray. Additionally, the 'Recovery of sensitive species' Common Indicator metric found that populations of the spotted ray were recovering in the Greater North Sea, Celtic Seas and Bay of Biscay and Iberian Coast (Regions II, III, IV).

For thornback ray, on the basis of ICES assessments the biomass indices and stock size indicators are increasing within OSPAR Regions II and III, either stable (ICES sub-area 8) or increasing (ICES division 9.a) in OSPAR Region IV, while catch rates around the Azores archipelago in OSPAR Region V are stable at a low level. Based on this evidence the overall conclusion on the species' status is positive and improving, although there is uncertainty (i.e., relatively wide confidence intervals) around some stock-related estimates, and indicative trends are relatively recent (i.e., over the last 5-10 years). Like all elasmobranchs this species is vulnerable to fishing mortality. Full details of this assessment can be found in OSPAR Overview assessment of implementation reporting. The FC1 metric results for thornback ray are in agreement with the POSH status assessment.

The white skate has disappeared from most areas of its former habitat, with few recent records from the English Channel, western Irish waters and Portuguese waters. No improvement in the status of this stock has been observed since the last OSPAR assessment (OSPAR 2010). Full details of this assessment can be found in OSPAR Status Assessment 2021 – White skate.

Table S.10: Summary of status assessments of OSPAR listed demersal fish

POSH assessments of demersal fish	Common skate					Spotted ray			Thornback skate/ray				White skate			Angel shark				Spurdog				
Region	**I**	**II**	**III**	**IV**	**V**	**II**	**III**	**IV**	**II**	**III**	**IV**	**V**	**II**	**III**	**IV**	**II**	**III**	**IV**	**V**	**I**	**II**	**III**	**IV**	**V**
Distribution	?	↔	↞	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?	?
Population size	?	↔	↔	?	?	↑	?	?	?	?	?	?	?	?	?	?	?	?	?	?	↑	↑	↑	↑
Condition, Demographics	low	low	low	low	low	?	?	?	?	?	?	?	?	?	?	?	?	?	?	↔	↔	↔	↔	↔
Previous OSPAR status assessment	●	●	●	●	●	●	●	●	●	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●
Status (overall assessment)	poor	poor	poor	poor	poor	good	?	?	good	good	good	?	poor	poor	poor	poor	poor	poor	?	poor	poor	poor	poor	poor

Regions where species occurs (○) and has been recognised by OSPAR to be threatened and/or declining (●)

↓ decreasing trend or deterioration of the criterion assessed

↑ increasing trend or improvement in the criterion assessed

←→ no change observed in the criterion assessed

? trend unknown in the criterion assessed

See: Common skate – Status Assessment 2021, Spotted ray – Status Assessment 2021, Thornback ray – Status Assessment 2021, White skate – Status Assessment 2021, Angel shark – Status Assessment 2021, Spurdog – Status Assessment 2021

OSPAR acts as a coordination platform in the North-East Atlantic for the regional implementation of the EU Marine Strategy Framework Directive (MSFD) that aims to achieve a Good Environmental Status (GES) in European marine environments, as well as for the coordination of other national frameworks. The characteristics of GES are determined by the individual EU member states, based on criteria elements, threshold values and methodological standards set regionally or at EU level.

Norwegian, Icelandic, United Kingdom, Greenlandic and Faroese marine areas are not covered by the MSFD.

I – Impact (on ecosystem services)

Impacts on the provision of ecosystem services by marine fish

Ecosystem services are the benefits that the environment brings to human wellbeing. Several anthropogenic pressures have been identified as responsible for impacting the ecosystem services (ES) linked to fish populations. The highest impacts have been observed on those ES where fish provide biomass and raw material to regulate food webs, even providing genetic material for aquaculture. Other services linked to fish are the regulation of climate change and sediment quality, or pest control: the impacts in these cases are low.

This section evaluates the impact that changes in the environmental state of fish, as described in the State section, exert on the ecosystem services that the North-East Atlantic provides. The section was developed through a literature review combined with expert judgement, using the same methodology across all thematic assessments. Several workshops involving ecosystem services experts and fish experts were held to discuss and agree the presented results. A detailed description of the anthropogenic pressures that impact fish state, and thus the provision of ecosystem services, is provided in the Pressure section. The following provides further details of the role that fish (and their state) have in relation to the provision of ecosystem services outlined in **Figure I.1**.

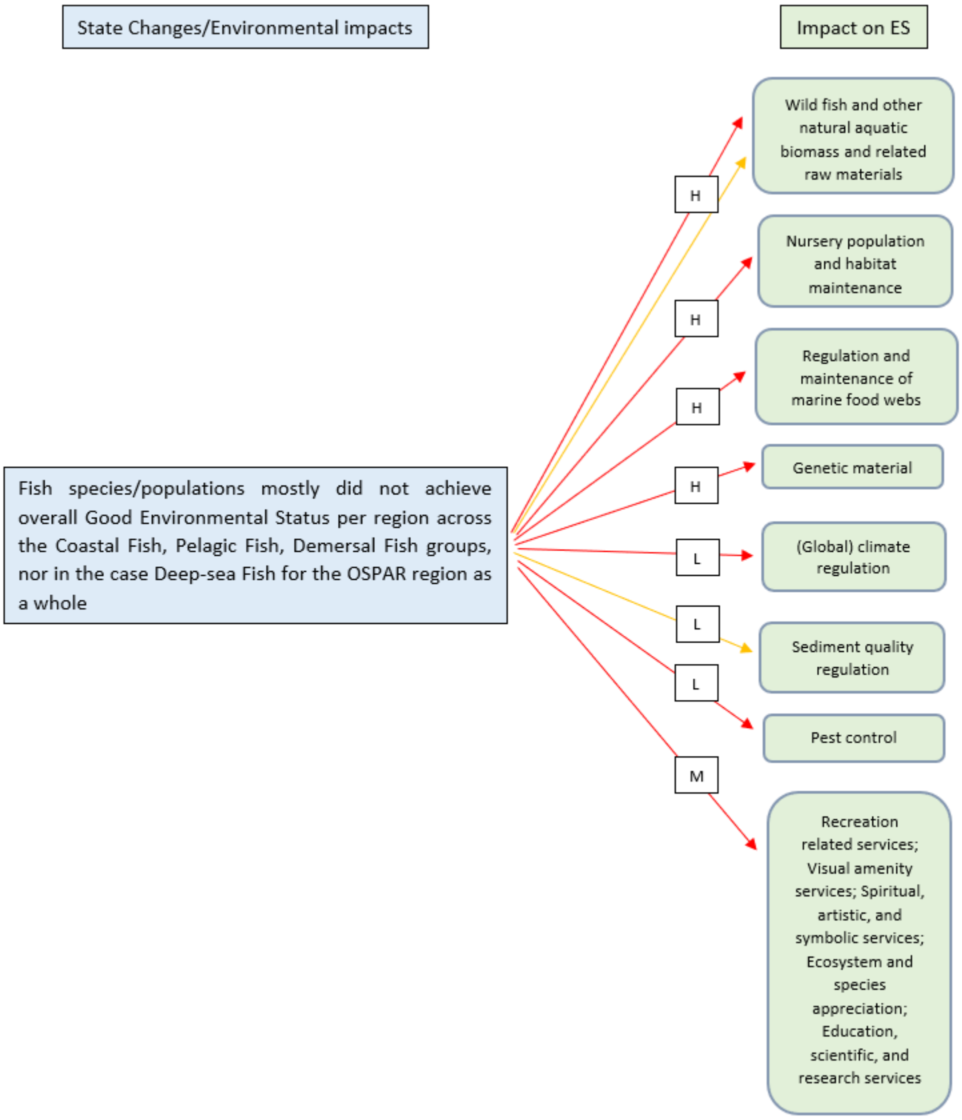


Figure I.1: Schematic depicting the 'State (changes)' - 'Impacts on ES' linkages for the Fish Thematic Assessment. The ecosystem services shown are those considered most relevant to the Fish Thematic Assessment. Each arrow also denotes an expert estimate of the nature and magnitude of the impact (yellow arrow = neutral impact, red arrow = negative impact; H = high impact, M = medium impact, L = low impact)

Wild fish and other natural aquatic biomass and related raw materials: Fish represent an important food source, not only for their natural predators but also for humans, directly through capture fisheries. Fish also represent critical biomass in aquaculture, both as feed and as a source of broodstock (Holmlund and Hammer, 1999).

It has been observed that decreases in fish body size (due to environmental pressures and impacts associated with human activities) can have negative consequences on egg production, nutrient transport and, in turn, on ecosystem services such as 'Regulation and maintenance of marine food webs' and 'Wild fish and other natural aquatic biomass and related raw materials' (Oke *et al*., 2020; Tavares *et al*., 2019).

This ecosystem service also contributes to activities such as recreational fishing, via biomass provisioning (Holmlund and Hammer, 1999).

Regulation and maintenance of marine food webs: Fish consumption of marine organisms plays an important role in regulating trophic structure by influencing the stability, resilience, and dynamics of the marine food web. Moreover, the role that fish play in regulating the balance of the food web changes as their life stages change. For example, a larval fish feeds on zooplankton, playing a role in controlling the latter's abundance. Adult stages of fish, which may be piscivorous, can exert strong top-down control along the food chain through predation of zooplanktivores (adult fish or larval stages feeding on zooplankton) (Hocevar and Kuparinen, 2021). Predation by piscivores leads to a decrease in predation pressure on zooplankton, which in turn increases the predation on phytoplankton. The degree to which fish influence the regulation of food web dynamics can vary depending on the physical and climatic conditions to which they are subjected (Holmlund and Hammer, 1999). For this reason, the environmental pressures associated with human activities that may lead to physical changes in the water, for example its temperature and chemical conditions, may in turn impact fish physically or non-physiologically (environmental impacts) and induce changes in the provision of the ecosystem service of maintenance of food web dynamics. Fish, including eggs and larvae, are also a source of food for various species of marine mammals and birds and passively contribute to sustaining the food web. Several tonnes of fish in the OSPAR Maritime Area are eaten annually by seabirds, which in turn produce phosphate-rich faeces that, when deposited on islands or in coastal areas, stimulate, for example, the production of macro-algae (Holmlund and Hammer, 1999). Moreover, large fish can contribute to food web maintenance and the enhancement of primary productivity via nutrient transport (Tavares *et al*., 2019). In this regard, the sensitive fish species that are considered by indicators such as 'Population abundance of sensitive fish species are those characterised by 'K-type' life-history traits (e.g., large body size), and these contribute to the maintenance of food webs (OSPAR 2017h; Tavares *et al*., 2019). In a similar way, a decline in the abundance of such species can negatively affect food webs (Tavares *et al*., 2019).

Nursery population and habitat maintenance: In recent years it has been argued that ecosystems should be considered not simply as made up of taxa (species and genus) but as groups of organisms with different life history traits (LHTs). These are characteristics like morphology, behaviour, demography and physiology (Violle *et al*., 2007). Exploring communities and ecosystems with approaches based on traits can help shed light on ecosystem functioning (Tavares *et al*., 2019). For example, in fish, body mass (trait) is associated with nutrient transport (ecosystem function) which, in turn, facilitates a contribution to the ecosystem service of 'Regulation and maintenance of marine food webs' by enhancing primary productivity (Tavares *et al*., 2019). Consequently, if these traits are adversely affected, for example due to habitat loss or exposure to pollutants, the provision of ecosystem services will also be negatively affected.

Many fish species have different habitat requirements throughout their life stages. For example, many spawn offshore and live in inshore or in coastal habitats as juveniles. Such behaviour is responsible for the flux of eggs and larvae towards the coast, where they represent an important food source for many juvenile individuals that will constitute the future adult biomass (Brown et al., 2022).

Genetic material: Fish act as important gene pool storage which contributes both as an intermediate ecosystem service to the provision of wild biomass (wild fish and other natural aquatic biomass and related raw materials), through gene and gamete supply, and as a final ecosystem service in which cells, tissues and/or the whole fish are taken from their natural environment and used for purposes such as blue biotechnology (Haines-Young and Potschin, 2018; Holmlund and Hammer, 1999). Thus, this ecosystem service also contributes to the ecosystem service of biomass and raw materials from *in-situ* aquaculture, as it provides genetic material for breeds development in aquaculture (Haines-Young and Potschin, 2018).

(Global) climate regulation: The oceans can function both as sinks and as carbon sources. Carbon fixation increases with high primary production. Fish populations and their changes in abundance can contribute to an increase or decrease in carbon fixation by the marine ecosystem. When, for example, zooplankton decrease following an increase in zooplanktivorous fish, primary producers (carbon fixers) increase and so does carbon fixation. However, the opposite situation can also take place, contributing to a (local) decrease in carbon fixation by primary producers (phytoplankton). This illustrates how variations in fish populations in relation to changes in food web dynamics ('Regulation and maintenance of marine food webs') can also contribute to climate regulation through indirect changes in carbon fluxes to the atmosphere (Holmlund and Hammer, 1999).

Sediment quality regulation: When fish spawn, rest or feed on or near the seabed, they can also contribute to influencing microbial communities in marine sediments and other conditions vital to benthic organisms (Holmlund and Hammer, 1999). For example, by excavating sandflats for food, fish such as stingrays cause oxygen and organic matter to penetrate deeper into the sediments, supporting the biogeochemical cycles and microbial communities that drive these processes (Hammerschlag et al., 2019). In addition, bioturbation (the mechanical action of moving the sediment) by fish can play an important role in nutrient-poor environments because nutrients released from the sediment into the water can be incorporated into primary production (Holmlund and Hammer, 1999). Thus, fish activity that contributes in part to the regulation of marine sediment quality can also contribute positively to the maintenance of the trophic web ('Regulation and maintenance of marine food webs') through a positive effect on primary production.

Pest control: Through their role in helping to maintain a balanced food web ('Regulation and maintenance of marine food webs'), fish also indirectly contribute to the ecosystem service of pest control. Pest control (from non-indigenous species to jellyfish bloom) is underpinned by a balanced food web and therefore all components of the marine ecosystem are relevant to the provision of this ecosystem service, including fish (Culhane *et al*., 2019).

Recreation-related services Onsite observation of fish, for example in reef habitat, can be done through activities such as diving (Holmlund and Hammer, 1999). Therefore, negative impacts on the health of fish and a decline in their abundance may in turn negatively impact the benefit that many people derive from non-consumptive activities.

Visual amenity services: Fish can convey a sense of place through direct observation or through artistic representations (for example, works of art that use marine wildlife as inspiration; UK NEA, 2011c). However, precisely because this ecosystem service can also be enjoyed offsite, for example through observation of artistic representations, a decline in fish can also have a neutral impact on this ecosystem service as it is not directly influenced by the current state of fish populations (Culhane *et al*., 2019).

Spiritual, artistic, and symbolic services: Fish can be a source of inspiration for various types of artistic expression, such as painting and drawing. However, precisely because this ecosystem service can be also enjoyed offsite, for example through artistic representations, a decline in fish abundance can also have a neutral impact on this ecosystem service as it is not directly influenced by the current state of fish populations (Culhane *et al*., 2019).

Ecosystem and species appreciation: This ecosystem service represents the value placed on species (charismatic or not) of fish simply by knowing that they exist and that they and their natural environment are in good state, even if perhaps the very people who place this value on them will never see them. This ecosystem service also includes knowing that future generations will have the opportunity to enjoy fish. Therefore, a significant decline in fish populations can negatively affect the provision of this service.

Education, scientific, and research services: The characteristics and functions of fish populations provide information to scientists and managers. For example, fish abundance is such that they can easily be sampled for gene composition, taxonomic and other studies (Holmlund and Hammer, 1999). Fish are a central topic in scientific research, as evidenced by the large number of studies involving fish found in various online literature databases. Also, the public display of captive fish, for example in aquariums, can make people more aware and appreciative of them. However, precisely because this ecosystem service can be enjoyed offsite, for example by visiting a museum, a decline in fish populations can also have a neutral impact on this ecosystem service as it is not directly influenced by the current state of fish populations (Culhane *et al*., 2019).

Public displays of captive fish can make people more aware and appreciative of them. © Shutterstock

R – Response

Measures taken in the OSPAR Maritime Area to manage and conserve marine fish

Section summary for the OSPAR Maritime area:

- The dominant pressure on fish populations in the North-East Atlantic is the extraction of biomass through fishing activities, which lies outside OSPAR's competence to manage; however, Article 4 of

Annex V of the OSPAR Convention requires it to cooperate with other competent bodies, an explicit objective of the NEAES 2030.

- OSPAR has identified 22 fish species that are considered to be under threat and/or in decline in the North-East Atlantic and has taken national and collective actions to protect and conserve 21 of these species.
- Fisheries management regulations have resulted in the harvesting of more fish stocks so as to move to levels considered sustainable, and a shift from fish stock management to an ecosystem perspective, with the introduction of measures to protect vulnerable habitats and species. However, concerns remain, including in relation to by-catch.

Fish R-section ANNEX: The section development has been supported by the collation of relevant measures: measures of relevance to fish communities included in this section

Section overview:

This section describes the responses for minimising the effect of human activities, their resulting pressures or impacts on the ecosystem services, and the aim to improve the state of fish in the North-East Atlantic. These responses can include the development of policy, legislation, and measures to manage or regulate specific human activities or to mitigate impacts on ecosystem services.

The full diversity of fish species within the OSPAR Maritime Area is considered in this section. It is recognised that only a sub-set of these species is represented in the indicator assessments, while another sub-set of fish species has been nominated by OSPAR Contracting Parties as being of particular concern and thus listed as threatened and/or in decline.

The primary focus is on the responses adopted by the OSPAR Commission for implementing the Contracting Parties' commitments under the OSPAR Convention and the strategic objectives of the North-East Atlantic Environment Strategy (NEAES) 2030. Article 22 of the OSPAR Convention requires that the Contracting Parties report to the OSPAR Commission at regular intervals on the steps they have taken to implement OSPAR Decisions and Recommendations, the effectiveness of those measures and the problems encountered in their implementation. This section aims to describe the progress made in implementing these measures and whether they are working in terms of achieving the ambitions set out in the NEAES 2030. The section attempts to set OSPAR's responses in the wider policy context and to examine the responses of other competent organisations, where these are pertinent to fish in the context of the North-East Atlantic. This wider perspective is particularly important, given that the dominant pressure on fish populations in the North-East Atlantic is the extraction of biomass through fishing activities, which themselves lie outside of OSPAR's competence to manage, as stated in Article 4, Annex V of the OSPAR Convention.

There are several entry points within the NEAES 2030 for future action relating to fish, in particular:

Strategic Objective 5: Protect and conserve marine biodiversity, ecosystems and their services to achieve good status of species and habitats, and thereby maintain and strengthen ecosystem resilience.

> **S5.O4:** By 2025 at the latest OSPAR will take appropriate actions to prevent or reduce pressures to enable the recovery of marine species and benthic and pelagic habitats in order to reach and maintain good environmental status as reflected in relevant OSPAR status assessments, with action by 2023 to halt the decline of marine birds.

S5.O5: By 2025 OSPAR will have implemented all agreed measures to enable the recovery of OSPAR Listed threatened and/or declining species and habitats and will take additional measures as needed.

S5.O6: Where the knowledge base is insufficient to achieve OSPAR's biodiversity objectives, OSPAR will take action to improve regional coordination for collection and sharing of data, information and knowledge, with elasmobranchs as a priority by 2023.

Strategic Objective 7: Ensure that uses of the marine environment are sustainable, through the integrated management of current and emerging human activities, including addressing their cumulative impacts.

S7.O6: OSPAR will work with relevant competent authorities and other stakeholders to minimise, and where possible eliminate, incidental by-catch of marine mammals, birds, turtles and fish so that it does not represent a threat to the protection and conservation of these species and will work towards strengthening the evidence base concerning incidental by-catch by 2025.

Cross-cutting issue:

SX.O2: By 2024 OSPAR will initiate discussions on the development of a practical approach for regional-scale ecosystem-based management, including through the 'Collective Arrangement' and in cooperation with fisheries management bodies and other competent organisations, in order to strengthen ecosystem resilience to climate change and to safeguard the marine environment, its biodiversity and ecosystem services.

There are a number of linkages to other thematic assessments, including: Food webs, Benthic Habitats, Pelagic Habitats, Eutrophication, Marine Litter, and Underwater noise.

The reader is referred to the following feeder reports for additional information on some of the key human activities affecting fish: Fisheries, Offshore Renewable Energy Generation, Aquaculture, Assessment of Data on the Management of Wastes or Other Matter (Dredged Material).

Measures adopted by OSPAR

This section focuses on measures that have been adopted by OSPAR and draw on efforts to protect and conserve fish species of particular concern, including the establishment of an ecologically coherent and well managed network of Marine Protected Areas, as well as specific measures that OSPAR has adopted to address human activities and pressures and improve the conservation status of these species.

The implementation status of all OSPAR measures was reported in 2021: Implementation of OSPAR measures - A progress report.

Addressing fish species in decline and under threat in the North-East Atlantic

OSPAR Contracting Parties have identified 22 fish species that are of particular concern in the North-East Atlantic and included in the OSPAR List of Threatened and/or Declining Species and Habitats (Agreement 2008-06) (the OSPAR List). The species listed include bony fish, sharks, skates and rays, commercially targeted species and those that are considered to be vulnerable– some highly mobile and others that tend to cluster.

The OSPAR List, which was first adopted in 2003 and updated in 2008 and 2021, guides the OSPAR Commission in setting priorities for its further work to conserve and protect marine biodiversity under Annex V to the OSPAR Convention. OSPAR Recommendations have been adopted for 21 of the listed fish species. The purpose of these Recommendations is to agree national and collective actions to strengthen the protection of the listed species, recover their status and ensure that they are effectively conserved in the OSPAR Maritime Area. A common understanding of the Recommendations was adopted in 2013 (Agreement 2013-13). The Recommendations are broad in nature, addressing a range of human activities and pressures. The actions to be taken nationally include steps to ensure appropriate national legislation for the protection of the listed fish species, consideration of how to strengthen the knowledge base, monitoring and assessment, steps to manage key human activities, calls for the designation of MPAs, and awareness raising. The collective actions include coordination of monitoring and assessment, enhanced knowledge exchange, collaboration and cooperation with relevant competent organisations in addressing key pressures such as fishing and shipping, and research.

The most recent implementation reporting took place in 2019, with the next round due in 2025. A detailed overview of the scope and range of actions implemented in this reporting round can be found in the OSPAR Overview assessment of implementation reporting. The level of implementation of the Recommendations varies considerably. OSPAR Contracting Parties have reported progress in their implementation for 20 of the listed fish species. The reporting did not include measures for the houting, as the Recommendation on furthering the protection and conservation of houting was only adopted in 2021, or for the bluefin tuna, for which OSPAR has not adopted any measure.

Progress in implementation of national actions

As stated in Article 4, Annex V of the Convention, OSPAR has agreed that no programme or measure concerning a question relating to the management of fisheries must be adopted under this Annex. However, where the Commission considers that action is desirable in relation to such a question, it must draw that question to the attention of the relevant competent authority or international body. Where action within the competence of the Commission is desirable to complement or support action by those authorities or bodies, the Commission must endeavour to cooperate with them.

Given the limitations on the programmes and measures that can be adopted on questions relating to the management of fisheries, the reports relating to all the Recommendations on fish species refer to actions being undertaken through relevant competent authorities and that help to implement the respective Recommendations. Within the EU, fisheries management actions are implemented through the Common Fisheries Policy, for example the Deep-sea Access Regulation (2016/2336), and environmental objectives through the EU Marine Strategy Framework Directive (MSFD). For diadromous species the EU Water Framework Directive (WFD) and the EU Habitats Directive were also noted as relevant. Equivalent national measures are found in non-EU Member States. Outside national jurisdiction, reports cited the implementation of regulations under the North-East Atlantic Fisheries Commission (NEAFC).

For **Bony fish** the engagement of Contracting Parties in national-level implementation is focused on the places where these species are considered to be of concern. The various actions have included the enactment of national legislation, both to protect species and, in the cases of the allis shad and sea lamprey, also their habitats; regulations governing the keeping of non-native fish species used for cultural purposes, for example the sturgeon; restoration, recovery and restocking efforts for a number of diadromous fish species such as salmon, eel and shad; and the use of area-based management. The Netherlands has highlighted the importance of eel grass (*Zostera* spp*)* restoration as a precursor to the return of the long-snouted seahorse in its waters. The reporting indicated that the monitoring routines for bony fish species were generally well established. The restoration of commercial species such as cod is a regular part of fisheries management routines and progress has been reported in the development of routines for deep-water species such as orange roughy (*Hoplostethus atlanticus*).

Sea lamprey. © T. Lawrence, Great Lakes Fishery Commission

Engagement and awareness-raising activities were reported for a number of species, including stakeholder meetings, awareness campaigns on species identification and stock status, the sharing of best fishing practice, and the production of guides, for example:

- Allis shad identification and handling guide for fishers;
- Identification guidelines to promote the release of sea lamprey from fishing gear;
- In Spain, a website for seahorse projects providing information on researchers to help share information and connect stakeholders: https://proyectohippocampus.iim.csic.es/proyectos.html.

Elasmobranchs There was very weak evidence of national measures being taken for highly mobile fish species such as elasmobranchs, partly because of reliance on fisheries management but also because of practical difficulties in targeting measures. In these cases, the emphasis could be placed more on collective actions to engage with the NEAFC, the EU and other relevant fisheries management bodies and, for areas outside national jurisdiction, to build on cooperation through the Collective Arrangement.

One example of sub-national action is the Wales angel shark action plan. This was developed in recognition of this species' sensitivity to accidental capture and its 58% decline in the Welsh and Irish waters that provide its key refuge.
Some EU Member States referred to having followed advice from ICES and the European Commission Scientific, Technical and Economic Committee for Fisheries (STECF) to inform their management. For sharks, EU Member States refer to the EU bans on landing and retaining these species. Outside the EU, there are bans in place for several of the listed shark species, including leafscale gulper shark, porbeagle, spurdog and Portuguese dogfish. France and Spain reported using the EU MSFD as a framework for restoring populations of gulper sharks, and there were a number of examples of the use of MPAs as a conservation measure (see section *The OSPAR network of Marine Protected Areas*).

The reporting indicated a high level of monitoring and research activity being carried out to improve knowledge of the distribution, life histories and behaviour of listed elasmobranch species. This ranges from commissioning new research to improving regular data collections. Several Contracting Parties indicate that they are working to improve the data that they submit to ICES for species assessments.

Some Contracting Parties are using population size, condition and distribution for sharks and rays as an indicator for MSFD reporting. Data collection for some shark species appears to use a varied approach, drawing on research projects but also combining academic input with citizen science.

Are these measures working?:
For the majority of OSPAR listed fish species, the status assessments suggest that the measures in place are having the desired effect of improving their conservation status. For many of these species, fishing is the biggest threat, the regulation of which is outside OSPAR's mandate. OSPAR Recommendations have generated a range of conservation actions at the national level, although it has been difficult to objectively assess the level of implementation of many, and at this stage it is not possible to state whether or not they have proven to be effective. The reporting has provided some good examples of other actions, such as awareness raising, including the development of identification guides and information campaigns. Several of these efforts were designed to help commercial fishers and on-board observers identify protected shark, skate and ray species and improve their reporting of by-catch. They include:

- HAROkit (http://www.vliz.be/nl/harokit): tools to support fishers to correctly identify sharks and rays;
- Shark Trust identification guides for all shark species with the support of government bodies. Their web pages provide a range of information on shark species, including the angel shark (www.sharktrust.org);
- An identification guide of sharks, rays and skates developed by the Swedish Species Information Centre, on commission from the Swedish Agency for Marine and Water Management, to help in identifying different species of sharks, rays and skates and thus improve the reporting of incidental by-catch. The guide has been distributed to all commercial fishers in the Swedish part of the Greater North Sea (Region II).

The reporting also included suggestions for strengthening actions that conserve the habitats on which certain fish species depend, building on the example of conserving *Zostera* beds for the long-snouted seahorse.

The adoption of a Roadmap for the implementation of collective actions within the Recommendations for the protection and conservation of OSPAR listed Species and Habitats (2017-2025) (The Roadmap) has supported the implementation of collaborative efforts across thematic boundaries within OSPAR, as well as informing or supporting actions implemented at the national level. However, it is not yet possible to report on the impact or effectiveness of these collective actions.

To improve our understanding of a measure's effectiveness, it is necessary to be able to track whether a response is reducing the human activity or pressure of concern, and whether that in turn results in an improvement in the status of the species in question. Progress is being made in understanding the linkages between activities, pressures and status, but there remain a number of challenges that limit the ability to determine whether or not the measures are effective: the need for more spatial data to fill large gaps, especially for beyond the coastal zone; the fact that the Recommendations address many actions – some specific, others more general, making it difficult to link cause and effect for individual actions and to determine where more effort could have the greatest effect; and finally, the need to take into account the time lag between taking an action and confirming whether it is having the desired effect. This time lag depends on a number of factors specific to each species' life history.

A number of the OSPAR listed fish species also feature in listings under other regional and global instruments, including the Prohibited Fish Species Lists under legislation within the EU's Common Fisheries Policy, the International Union for Conservation of Nature (IUCN) Red List (2010), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (for EU Member States transposed into Council Regulation 338/97), the Convention on the Conservation of Migratory Species of Wild Animals (CMS) and the EU Red List. Where there are overlaps in the species listings, this is identified in the relevant OSPAR Recommendation. The EU Habitats Directive is relevant for a very small number of diadromous fish, with crossover for two species on the OSPAR List, namely sturgeon (*Acipenser sturio*) and houting (*Coregonus oxyrhynchus*), and emphasis placed on the freshwater phase of the lifecycle.

Inclusion of listed fish species within Environmental Impact Assessments

Consideration of the approval of marine licences for certain activities and projects must include some kind of environmental impact assessment (EIA). In 2010 OSPAR adopted Recommendation 2010-05, with the aim of ensuring that the features of the OSPAR List are specifically taken into consideration when environmental impact assessments (EIAs) of human activities are prepared. The most recent reporting on the implementation of Recommendation 2010/05 took place in 2020. Contracting Parties that are EU Member States reported that they give effect to this Recommendation through national legislation adopted to implement the EU Environmental Impact Directive (2014/52/EU). Some Contracting Parties also point to other relevant legislation that complements their EIA and strategic environmental assessment (SEA) obligations. For example, the EU Habitats Directive (Council Directive 92/43/EEC), including the Natura 2000 network and the Habitats Directive assessments, as a requirement for any plan or project likely to have an effect on a protected site, and the EU Marine Strategy Framework Directive (Directive 2008/56/EC). The United Kingdom Fisheries Act contains an obligation to minimise and where possible eliminate by-catch of sensitive marine species. It encompasses the relevant species in the OSPAR List and covers the significant human impact of fisheries. Another example is the EU Deep-sea Access Regulation (2016/2336), which requires an EIA for exploratory fishing in areas where fisheries have not previously existed.

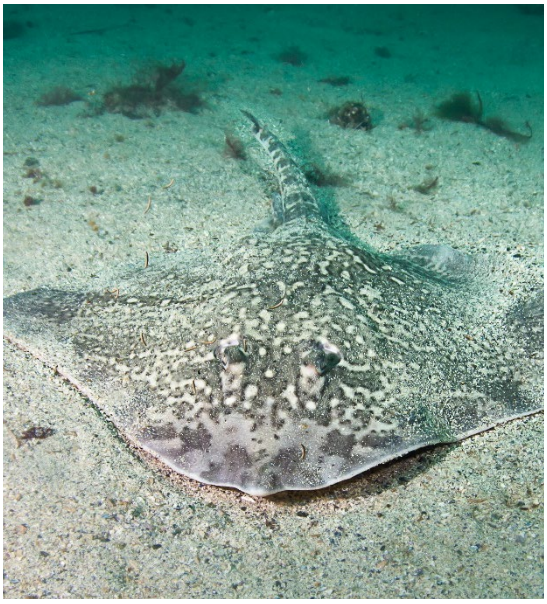
Is the measure working?

Overall, the approach of using EIA and SEA legislation is an important mechanism to promote the protection of OSPAR listed threatened and/or declining species and habitats. The fact that the OSPAR List (Agreement 2008-06) and OSPAR Recommendation 2010/05 are non-binding can mean that effective implementation is dependent on overlaps with national practice.

Current reporting on the application of Recommendation 2010/05 focuses on the extent to which species and habitats on the OSPAR List are expressly included within the scope of EIAs/SEAs; it is not possible to determine whether these assessments have resulted in effective mitigation measures or otherwise resulted in the reduction of impacts, and this could be a useful area for further good practice sharing. Lack of knowledge about the distribution and status of habitats has been identified as a practical barrier.

Within the NEAES 2030 (S5.O3), OSPAR will establish a mechanism by 2024 to provide that, where Contracting Parties are authorising human activities under their jurisdiction or control that may conflict with the conservation objectives of OSPAR MPAs in the ABNJ, those activities are subjected to an Environmental Impact Assessment (EIA) or Strategic Environmental Assessment (SEA).

Basking shark. © Chris Gotschalk



Thornback ray. © Shutterstock

The OSPAR network of Marine Protected Areas

Within OSPAR, Marine Protected Areas (MPAs) are understood as areas for which protective, conservation, restorative or precautionary measures have been instituted for the purpose of protecting and conserving species, habitats, ecosystems or ecological processes in the marine environment. In 2003, OSPAR adopted Recommendation 2003/03 to establish an ecologically coherent and well managed network of MPAs; this was then amended in 2010. By 1 October 2021, the OSPAR network of MPAs numbered 583, including eight that had been collectively designated in ABNJs. The network of MPAs has a total surface area of 1 468 053 km^2, covering 10,8% of the OSPAR Maritime Area, thus achieving the spatial coverage component of Aichi Biodiversity target 11 of the United Nations Convention on Biological Diversity (CBD) and Sustainable Development Goal 14, target 14.5, namely, to conserve at least 10% of coastal and marine areas by 2020. Report and assessment of the status of the OSPAR network of Marine Protected Areas in 2021.

MPAs as a response for the conservation of fish species

Concerning other mobile species, MPAs are a tool forming part of a wider suite of management measures. MPAs offer the potential to reduce or remove activities and pressures in those critical locations that may have implications for the conservation status of fish species, with particular focus on vulnerable species that have clumped or discrete population distributions. Examples reported within this species grouping included the designation of MPAs for seahorses, lamprey, common skate complex and cod. MPAs also play an important role in creating migratory corridors for highly mobile fish species.

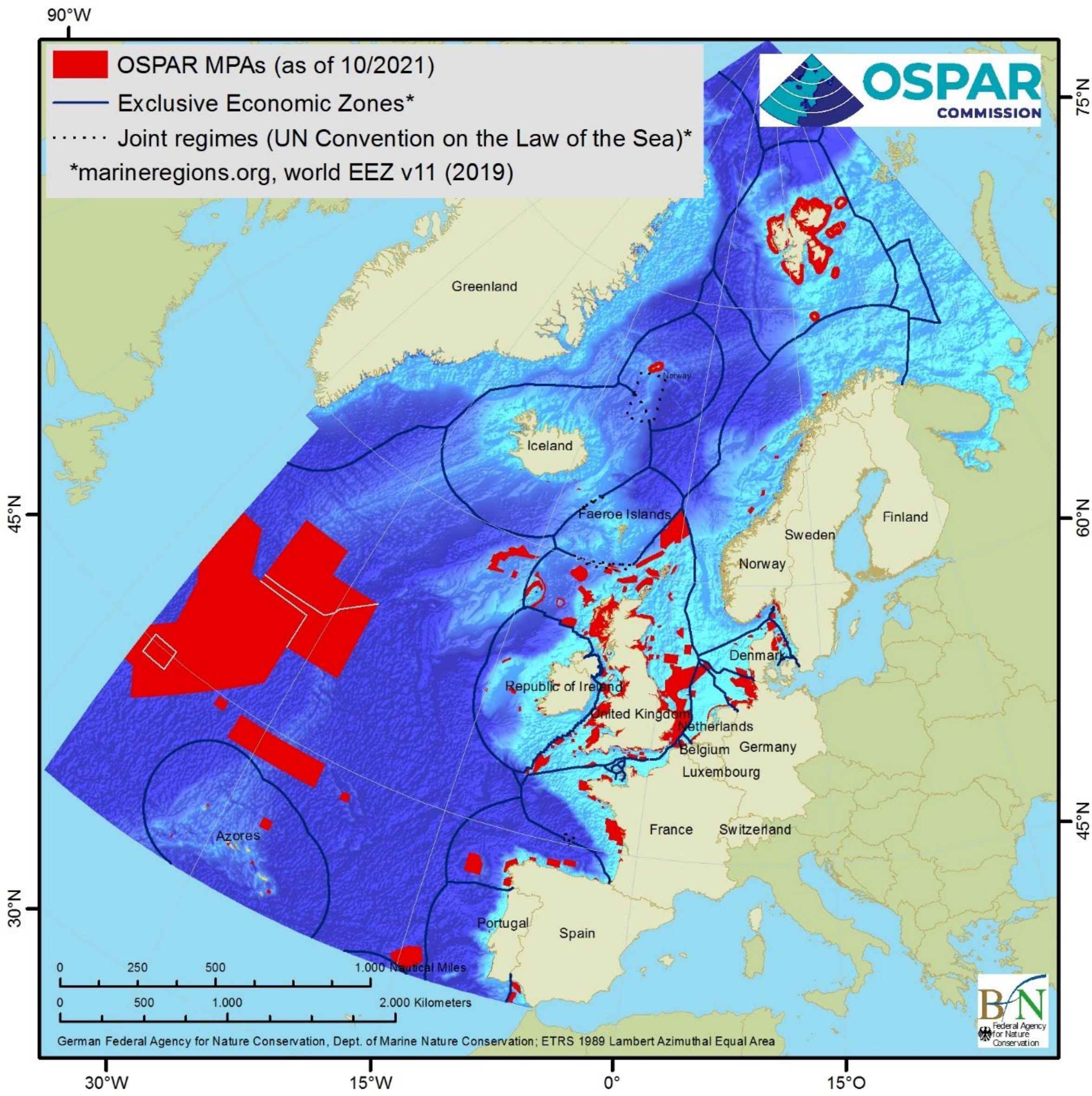
MPAs are the only explicit management measure within the EU MSFD. OSPAR's work can add value to fish species conservation through the development of an ecologically coherent and well-managed network of MPAs within and beyond areas of national jurisdiction, with particular focus on vulnerable species such as large elasmobranchs (skates, rays, angel shark, etc.) or species with clumped or discrete population distributions such as the seahorse or sea lamprey.

The Recommendations for the conservation and protection of fish species listed as threatened and/or declining by OSPAR include an action to consider sites that might justify selection as Marine Protected Areas for populations of these species.

The 2019 implementation reporting against these Recommendations identified a number of examples of action taken by OSPAR Contracting Parties at the national level. Seven Contracting Parties have designated MPAs with sea lamprey as a qualifying feature; coherent protection and management of estuaries and rivers was noted as a key factor in the case for this species. One Contracting Party reflected that its inland fisheries management authority is implementing a lamprey reporting project that may drive future site selection. Six Contracting Parties have shad as a designated feature at multiple MPAs, including areas important to that species for foraging, breeding and migration.

There was evidence of national MPA measures being taken for skate species in the United Kingdom and in Spain, where two marine areas relevant to thornback ray have been protected (El Cachucho MPA-SAC and Banco de Galicia SCI) and included in the OSPAR MPA network. No sites have been selected for the common skate complex.

Contracting Parties expressed differing views regarding the implementation of MPAs for the protection and conservation of shark species. In the main, Contracting Parties reported that these species are highly mobile or occur in very low numbers, or that it had not been possible to identify critical habitat and MPA designation was therefore not considered suitable. The United Kingdom was undertaking consultation on a proposed MPA to protect basking shark, but the outcome was not reported. Spain reported MPAs in its waters that are relevant to some shark species, including the Portuguese dogfish, the leafscale gulper shark and the gulper shark.



OSPAR Network of MPAs (as of 1 October 2021). Source: [OSPAR]

Ecological coherence of the OSPAR MPA network for fish species

The criteria for understanding whether the MPA network can be considered ecologically coherent include how well represented the OSPAR listed marine fish species are within the network (representativity) and the number of MPAs where these species occur (replication) – see **Table R.1**. This factor can help identify where the network may need to be further strengthened; it is not presented as an assessment of the measures in place or of their implementation. For widely distributed and/or highly migratory species, MPAs may need to be sufficiently large to encompass the species' entire distribution. In this instance, other means to regulate fishing mortality would be appropriate.

The one out, all out principle applies, so that, if there is either insufficient representativity or replication within the network for one region where the species is under threat and/or decline, the ecological coherence criterion is not met. Only four of the 20 species of fish listed by OSPAR as threatened and/or declining (with Recommendations in place) are considered to be adequately represented and replicated by the OSPAR MPA network. Attention is required across all OSPAR Regions, to varying degrees.

Table R.1: Overview of the ecological coherence (representation and replication) of threatened and declining fish species within the OSPAR MPA network (Source: Table 2.6 of the 2021 MPA status assessment)

Key: Green = *There is MPA protection in OSPAR Region(s) where the species is considered to be under threat/ subject to decline*; Red = The species is not protected in a Region where it is considered to be under threat and subject to decline; Grey = The species is not known to occur in that Region; White = The species is present in the Region and protected but not considered to be under threat or in decline. The number indicates MPAs where a species is identified as a conservation objective.

OSPAR T&D fish species	I - Arctic Waters	II - Greater North Sea	III - Celtic Seas	IV - Bay of Biscay and Iberian Coast	V - Wider Atlantic
Acipenser sturio - Sturgeon		0		4	
Alosa alosa - Allis shad		8	5	12	
Anguilla Anguilla - European eel	0	11	12	8	1
Centrophorus granulosus - Gulper shark				1	8
Centrophorus squamosus - Leafscale gulper shark	1	1	1	1	9
Centroscymnus coelolepis - Portuguese dogfish	0	1	1	1	9
Cetorhinus maximus - Basking shark	0	1	2	3	3
Coregonus lavaretus oxyrinchus - Houting		10			
Dipturus spp - Common Skate complex	0	3	3	1	0
Gadus morhua - Cod	0	14	1	0	0
Hippocampus guttulatus - Long-snouted seahorse		4	4	7	2
Hippocampus hippocampus - Short-snouted seahorse		12	1	5	0
Hoplostethus atlanticus - Orange roughy	0			1	8
Lamna nasus - Porbeagle	0	2	2	0	1
Petromyzon marinus - Sea lamprey	0	16	9	6	
Raja clavata - Thornback ray	0	2	1	5	4
Raja montagui - Spotted Ray		3	1	3	0
Rostroraja alba - White skate		1	0	1	0
Salmo salar – Salmon - Salmon	2	7	4	7	
Squalus acanthias - [North-East Atlantic] spurdog	0	3	1	0	1
Squatina squatina - Angel shark		0	1	0	
Thunnus thynnus - Bluefin tuna *				2	5

* *Recommendation pending*

Management status of the OSPAR MPA network

At the 2010 OSPAR Ministerial Meeting in Bergen, Norway, OSPAR ministers committed to ensuring that the OSPAR MPA network is well managed, namely that coherent management measures have been set up and are being implemented to achieve the conservation objectives of the protected features of OSPAR MPAs. While there is no formal agreement on what constitutes 'well managed' in terms of an MPA, four questions have been posed to help understand the progress of implementation: whether the MPA management has been documented, whether measures to achieve the conservation objectives of the MPA are being implemented, whether monitoring is in place to assess if the measures are working and, finally, whether the MPA is moving towards its intended conservation objectives.

OSPAR has made progress in managing the MPA network. The 2021 status assessment showed that 88% of OSPAR MPAs have either full or partial management information in place which is publicly documented. The report showed a 17% rise in the implementation of measures considered to be required to achieve conservation objectives, signifying an overall 83% increase since assessments began in 2016. Another area of improvement is the increase in monitoring to detect progress made towards achieving conservation objectives. The assessment showed that 75% of OSPAR MPAs have either full or partial monitoring programmes in place, albeit these are largely based on the ability to monitor sea users' compliance with the rules and regulations associated with OSPAR MPAs, as opposed to direct site condition monitoring, which is costly. Nearly half of OSPAR MPAs are thought to be moving towards achieving their conservation objectives. It is important to note that this percentage has increased over time, from 36%, then 44% and 49%, in 2016, 2018 and 2021, respectively. Despite improvements in understanding the management status of the MPA network, it is still difficult to determine whether the protected features of the OSPAR MPAs are moving towards their conservation objectives owing to lack of site-specific information or long-term monitoring programmes, as noted above.

Future OSPAR work should focus on implementing the management measures considered necessary to achieve the conservation objectives of the protected features of MPAs. In parallel, there is a need to establish long-term monitoring programmes to evaluate the effectiveness of management measures and be able to conclude with greater confidence whether the conservation objectives of the protected features of MPAs are being achieved. In addition, work should progress on improving methods of evaluating the degree to which the OSPAR MPA network is capable of managing a more sophisticated assessment of whether the network is delivering a genuine conservation benefit to targeted habitats, species and ecological processes, as well as to the wider marine environment.

Regarding OSPAR MPAs in ABNJs, Contracting Parties are committed to coordinating on MPA objectives through their national delegations to other relevant competent organisations. There should be continued effort to further the Collective Arrangement (OSPAR Agreement 2014-09) and to cooperate through other mechanisms, such as Memoranda of Understanding, with relevant competent authorities, enabling them to consider the appropriate management actions to help deliver the conservation objectives for OSPAR MPAs in ABNJs.

Is this measure working?:
OSPAR is progressing towards key metrics in terms of area-based protection; however, there are still gaps in geographic coverage (particularly in the Arctic region), ecological coherence and in the understanding of whether or not management is effective. The 2030 North-East Atlantic Environment Strategy (NEAES 2030) commits the Contracting Parties to further development of the OSPAR network of MPAs and other effective area-based conservation measures (OECMs) by 2030, in order to cover at least 30% of the OSPAR Maritime Area and ensure that it is representative, ecologically coherent and effectively managed to achieve its conservation objectives (Objective S5.O1 of the NEAES 2030). This ambition is in line with the global target under negotiation within the Convention on Biological Diversity.

The OSPAR mandate is restricted when it comes to the management of certain human activities such as fisheries. Here, effective implementation relies on action by the Contracting Parties for areas within national jurisdiction, and with other competent organisations in areas beyond national jurisdiction. However, the common ambition of a regionally coherent network is important and brings useful attention to the protection of threatened and /or declining habitats. Under the NEAES 2030, OSPAR has committed to establishing a mechanism by 2024 to provide that, where Contracting Parties are authorising human activities under their jurisdiction or control that may conflict with the conservation objectives of OSPAR MPAs in ABNJs, those activities are subjected to an Environmental Impact Assessment (EIA) or Strategic Environmental Assessment (SEA).

The requirement for regular reporting provides a valuable mechanism for tracking progress and accountability. There is, however, a need to continue improving the availability of data relating to the OSPAR MPA network in order to inform those responsible for managing the various human activities in the marine environment. This includes providing information on protected features, and the management plans that are in place, and the development necessary in order to deliver on NEAES S11.O2: "By 2023, and every six years thereafter, OSPAR will assess at a regional scale the OSPAR network of marine protected areas in respect of the resilience of marine biodiversity to climate change, with the aim of ensuring that the network provides a good representation of species and habitats and that its spatial design and management regime remains relevant."

Understanding the management effectiveness of the MPAs within the network and of the network itself, remains an important gap to address. By 2022, OSPAR has committed to identifying barriers to the effective management of MPAs and, by 2024, to taking steps to address them appropriately to enable all OSPAR MPAs to achieve their conservation objectives (NEAES S5.O2).

Other OSPAR measures responding to relevant human activities and pressures:

Fish and shellfish harvesting (professional, recreational) [Extraction of living resources]:

The Collective Arrangement between competent international organisations on cooperation and coordination regarding selected areas in areas beyond national jurisdiction in the North-East Atlantic (Collective Arrangement, OSPAR Agreement 2014-09) is a formal agreement between legally competent authorities with responsibility for managing human activities in the Areas Beyond National Jurisdiction (ABNJs) in the North-East Atlantic. To date, the Arrangement has been adopted by the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the North-East Atlantic Fisheries Commission (NEAFC) and focuses on selected geographic areas. In the case of OSPAR, the Arrangement applies to MPAs designated outside national jurisdiction, and in the case of the NEAFC, it applies to certain areas with fishery closures. The respective organisations maintain a list of these areas in Annex 1 to the Arrangement. There is a strong overlap in these geographic regions enabling each to act within its own field of competence in a manner that is coherent and complementary.

The Collective Arrangement has successfully provided a framework for productive dialogue not only between OSPAR and the NEAFC, but also with other relevant competent organisations. In 2017, a joint commitment was submitted, under target 4.c of SDG 14, which commits both secretariats to further promoting the Collective Arrangement and widening its collaborative scope with the secretariats of other intergovernmental organisations and bodies in other regions and sectors.

Please refer to *Important measures taken by other competent bodies* for more information about measures implemented by other competent organisations relevant to OSPAR's work, OSPAR Feeder Report 2021 -

Fisheries and to *Gaps and Opportunities* to read more about the gaps and opportunities for OSPAR under the NEAES 2030.

Renewable energy generation (wind, wave and tidal power), including infrastructure, Nuclear energy and, Transmission of electricity and communications (cables) [Production of energy]: OSPAR Feeder Report 2021 – Offshore Renewable Energy Generation

Commitments to increase renewable energy production are leading to the rapid and, in some areas, extensive development of marine renewable infrastructure. In 2008, OSPAR produced guidance on the environmental considerations for offshore wind farm development (OSPAR 2008-03). This guidance is intended to help approval authorities identify issues that might be associated with the environmental impacts of development at all stages of operation and decommissioning, including the avoidance of impacts on fish at their different life stages. In the case of fish, the siting of structures should avoid essential habitats such as nursery zones, spawning grounds and migration routes. Food webs could also be impacted by fish aggregation, collision risks, electromagnetic fields from cables, and behavioural responses to noise, although all of these require further research and monitoring.

The guidance also refers to other measures relevant to managing the impacts of renewable energy infrastructure development, including the EU Habitats Directive (92/43/EEC) and Environmental Impact Assessment Directive (2014/52/EU). A 2020 survey of OSPAR Contracting Parties showed that the offshore wind guidance was generally being fully implemented or that implementation was in progress, although not all Contracting Parties provided information for the survey. OSPAR also maintains a database of individual marine renewable developments, including tidal and wave as well as offshore wind.

For OSPAR Contracting Parties that are also EU Member States, the European Commission's offshore renewable energy strategy (2020/741) refers to the Birds and Habitats Directives to ensure that developments do not have negative impacts on listed species or habitats, and that any potential impacts are reduced or minimised. Guidance has been developed under the EU (Commission notice (2020) 7730) as well as the Wildlife Sensitivity Mapping Manual, which provides practical guidance for renewable energy planning within the European Union. OSPAR's NEAES 2030 states: "By 2023, OSPAR will develop common principles and by 2024 develop guidance to promote and facilitate sustainable development and scaling up of offshore renewable energy in a way that cumulative environmental impacts are minimised." (S12.O4)

Extraction of oil and gas, including infrastructure and Extraction of minerals [Extraction of non-living resources]:
OSPAR Feeder Report 2021 - Extraction of non-living resources

Aggregate extraction: Management of aggregate extraction is carried out in accordance with ICES (and OSPAR) guidelines (OSPAR Agreement 2014-06), which ICES considers fit for purpose). However, the ICES guidelines are subject to a forthcoming review.

Coastal defence and flood protection, Land claim, Canalisation and other water course modifications, and Restructuring of seabed morphology, including dredging and depositing of materials [Physical]:

The dredging and the dumping of waste and other matter has been well regulated since the Oslo Convention came into force in 1974. OSPAR has adopted Guidelines for the management of dredged material at sea

(Agreement 2014-06), designed to assist Contracting Parties in managing dredged material in ways that will prevent and eliminate pollution in accordance with Annex II to the 1992 OSPAR Convention, and to protect marine species and habitats in the OSPAR Maritime Area in accordance with Annex V. These set out a Best Environmental Practice approach for minimising both the amount of material dredged and the impacts of dredging and disposal. The Guidelines include specific information on appropriate placement of dredged material in relation to the OSPAR List of Threatened and/or Declining Species and Habitats (OSPAR Agreement 2008-06). National authorities use the Guidelines to manage dredging and dumping and to minimise effects on the marine environment; they serve as a tool that Contracting Parties which are also EU Member States can use to manage dredged material that is subject to current European Directives (such as Water Framework Directive 2000/60/EC, Marine Strategy Framework Directive 2008/56/EC, the Natura 2000 areas under the Birds and Habitat Directives 2009/147/EC and 92/43/EEC). Directive 2008/98/EC of the Parliament and of the Council of 19 November 2008 on Waste (the Waste Framework Directive) has also been identified by Contracting Parties as having implications for the management of dredged material, in addition to relevant national legislation.

Since 2000, the assessment and licensing procedures for dredged materials in most OSPAR countries have included action levels for contaminant loads based on the OSPAR Guidelines. Since 1998, OSPAR has also had guidelines in place on the dumping of fish waste (OSPAR Agreement 1998-21). The management of dredged material should respect natural processes of sediment balance. Selecting the appropriate location for a dumpsite is essential for minimising environmental impact. Several dumpsites have been relocated by applying the OSPAR Guidelines. For example, a planned site in the Weser estuary was relocated after a site survey detected a mussel bank. Dumpsites have also been relocated or closed to avoid impacts on MPAs, fisheries and shipping. The ban on dumping vessels or aircraft has been implemented successfully.

A report on the use of the OSPAR Guidelines for the management of dredged material at sea was presented to OSPAR's Environmental Impacts of Human Activities Committee (EIHA) in 2020. Contracting Parties reported that the guidelines were being fully implemented in the majority of the OSPAR Maritime Area (§6.46 OSPAR Feeder Report 2021 - Shipping). Under the NEAES 2030, OSPAR will assess, review and potentially revise the OSPAR criteria, guidelines and procedures relating to the dumping of wastes or other matter and to the placement of matter by 2023 (S7.O4).

Marine litter

OSPAR Marine Litter Thematic Assessment

Marine litter has the potential to detrimentally impact both fish populations and fishery activities, and fishery activities also provide a pathway for the introduction of marine litter.

The first OSPAR Regional Action Plan for Marine Litter contained a range of national and common actions to be taken by OSPAR Contracting Parties to combat marine litter (OSPAR Agreement 2014-01). In 2022 OSPAR adopted the Second Regional Action Plan for Marine Litter (OSPAR Agreement 2022-05) and will continue the work to prevent and significantly reduce marine litter in the North-East Atlantic. It incorporates an action to build an evidence base for understanding harm and developing appropriate measures; an action to prevent abandoned, lost and discarded fishing gear; continued support for the Fishing For Litter initiative (Recommendation 2016/01); a scheme that works with key stakeholders to remove marine litter from the sea and the seabed; and actions to implement and progress awareness raising, including a recommendation on sustainability education programmes for fishers (OSPAR Recommendation 2019/01).

The OSPAR Marine Litter Thematic Assessment reports that there are positive signs of a decrease in the quantities of litter found on OSPAR beaches and of floating litter in the North Sea over the last 10 years. When considered against the upward trend in plastic production and consumption in Europe over a similar period, this suggests that progress has been made in preventing plastics from entering the marine environment. The successful implementation of OSPAR's Second Regional Action Plan will be crucial to building and maintaining the momentum for achieving OSPAR's objective to prevent inputs of and significantly reduce marine litter.

Other relevant activities

There are a number of other human activities with relevance to the status of fish populations on which OSPAR has not taken measures. These include tourism and leisure infrastructure and leisure activities. Urban and industrial uses, transport, dredging aspects relating to shipping, and infrastructure are included under coastal defence, land claim and other considerations. Responses relating to aquaculture are referred to in *Important measures taken by other competent bodies* below.

Important measures taken by other competent bodies:

This section highlights measures taken by other competent bodies that are relevant for improving the status of fish in the North-East Atlantic. As stated above, the extraction of fish biomass through fisheries activities is the most significant human activity affecting the status of fish populations in the North-East Atlantic and is the focus of this section.

General conservation measures

Under the EU Marine Strategy Framework Directive (2008/56/EC), biodiversity-related aspects of fish are reported under Descriptor 1 (Biodiversity), with some aspects of fish community status included under Descriptor 4 (Food webs). Commercial fish species are reported under MSFD Descriptor 3 (Commercial fish and shellfish), which specifically addresses the impact of fishing activities on target species, and under which the goal of Good Environmental Status (GES) is deemed to have been reached when: "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock". Descriptor 6 is also relevant, as it relates to the structure and function of the seafloor and benthic ecosystems, important for supporting many fish species. There are established connections between the MSFD and the Common Fisheries Policy in its latest form.

Fish and shellfish harvesting (professional, recreational) and Hunting and collecting for other purposes [Extraction of living resources]:

OSPAR Feeder Report 2021 - Fisheries

As noted above, OSPAR does not itself have the competence to address questions relating to the management of fisheries. However, given that this is the most important human activity affecting fish communities, OSPAR maintains a watching brief on responses taken to address fisheries management by the relevant competent organisations.

Fisheries management responses are set within the context of the global framework for fisheries management and the common principles set out in the United Nations Convention on the Law of the Sea (UN, 1982 (known as UNCLOS)), which includes a call for a maximum sustainable yield (MSY) approach to managing fisheries; the United Nations Conference on Environment and Development (UN, 1992a (known as UNCED)), including Chapter 17 of Agenda 21 which highlights a precautionary approach. The United Nations Fish Stocks Agreement of 1995 (UN, 1995 (known as the UNFSA)) and the 1995 FAO Code of Conduct for responsible fisheries also call for a precautionary approach.

Within the North-East Atlantic, the key responses are the national fisheries management legislation of those Contracting Parties that are not EU Member States and the EU Common Fisheries Policy (CFP) for those Contracting Parties that are also EU Member States. Also, the Regional Fisheries Management Organisations (RFMOs) manage particular aspects of fisheries within the North-East Atlantic, including the North East Atlantic Fisheries Commission (NEAFC), which regulates certain fisheries outside of national jurisdiction, the International Commission for the Conservation of Atlantic Tunas (ICCAT) and the North Atlantic Salmon Conservation Organization (NASCO).

The Common Fisheries Policy (CFP, 1380/2013 as amended by 2017/2092) is a set of rules for sustainably managing European fishing fleets and conserving fish stocks. Sitting within the CFP and important in its own right is the Regulation on the conservation of fishery resources and the protection of marine ecosystems through a set of technical measures, adopted in 2019 (2019/1241). It provides for important measures regulating by-catch, vulnerable marine ecosystems (VMEs) and the conservation of commercial fish. The Regulation sets out technical measures concerning: (a) the taking and landing of marine biological resources; (b) the operation of fishing gear; and (c) the interaction of fishing activities with marine ecosystems, including the use of closed areas, the prohibition of catches of certain species and regulations on gear. While the primary role of the Regulation is to support CFP implementation, it also aligns with the objectives of EU conservation regulations including the Habitats Directive, the Birds Directive, and the MSFD.

All the non-EU coastal states in the OSPAR Maritime Area have fisheries management regulations analogous to those under the EU CFP. These coastal states are Iceland, Denmark in respect of the Faroe Islands and Greenland, the United Kingdom and Norway. In addition, the NEAFC is responsible for the regulation of high seas fisheries (those beyond coastal states' exclusive economic zones). **Case Study from Benthic TA: – The Norwegian national measures for holistic management of open seas marine ecosystems, including benthic habitats**

Examples of responses to address by-catch: NEAFC has implemented a number of measures relating to by-catch and discards. The unregulated use of gillnets in deep water is potentially damaging to deep-water stocks owing to excessive soak times and consequent high discard levels, and the long-term impact of lost or abandoned gears. Accordingly, until measures are adopted by the NEAFC to regulate these fisheries, vessels operating in the NEAFC Regulatory Area are not allowed to deploy gillnets, entangling nets or trammel nets at any position where the charted depth is greater than 200 m. All such nets have been removed from the NEAFC Regulatory Area since 1 February 2006. In 2010 the NEAFC adopted a discard ban which was subsequently extended in 2023, with each Contracting Party ensuring that its fishing vessels operating in the Regulatory Area are prohibited from discarding or releasing catches of any of the species listed in the binding Recommendation. The NEAFC also bans the targeting of the following deep-water species on the OSPAR List: gulper shark, leafscale gulper shark, Portuguese dogfish, porbeagle, and basking shark. Article 7 of the NEAFC Scheme of Enforcement requires a series of actions to be taken by NEAFC Contracting Parties in order to reduce abandoned, lost or discarded fishing gear, marine debris, and by-catch through ghost gear.

Management and conservation of deep-sea fisheries: There are examples of responses to manage impacts on habitats or species that are particularly vulnerable. These measures are informed by ICES scientific advice, and there is strong alignment between its list of vulnerable species and habitats and the deep-sea species and habitats on the OSPAR List. The NEAFC has had in place measures to protect Vulnerable Marine Ecosystems from bottom fishing since 2005. These measures, including restricted and closed areas, are consolidated in Recommendation 19:2014, as amended. The NEAFC also has an approach in place to protect deep-sea stocks from unsustainable exploitation, in the form of the NEAFC Approach to Conservation and Management of deep-sea species (2016) combined with the Deep-Sea Fisheries Recommendation, 9:2018. Furthermore, EU 2016/2336 Regulation (EU) 2016/2336 of the European Parliament and of the Council of 14 December 2016 aligns with the relevant resolutions of the UN General Assembly, in particular Resolutions 61/105 and 64/72. It sets out specific measures for regulating fishing in the deep seas as well as the international waters of the North-East Atlantic and is known as the Deep-sea Regulation. It aims to improve knowledge and prevent adverse impacts on VMEs, thus ensuring the long-term conservation of deep-sea fish stocks.

NEAFC has also implemented a series of recommendations on vulnerable species of concern to OSPAR. For example, Recommendation 2020-08 focuses on the conservation and management of the basking shark, prohibiting directed fishing and requiring release. These recommendations are based on the advice of the ICES and reviewed periodically.

IUU fishing: Illegal, unregulated or unreported fishing activity (IUU), in contravention of fisheries agreements and management regimes, poses a significant global threat to fish stocks and the wider ocean ecosystem. Globally, the OSPAR Contracting Parties (whether individually or within the EU) are parties to the FAO Agreement on Port State Measures to Prevent, Deter and Eliminate Illegal, Unreported and Unregulated Fishing (PSMA), which came into force in 2016. NEAFC implements a Port State Control system which preceded the PSMA and is aligned with or exceeds its minimum standards. This sets out measures which parties must apply when foreign vessels seek entry into ports, thus blocking the marketing of fish captured by IUU fishing (more information in FAO, 2023). Within the OSPAR Maritime Area, the controls on IUU fishing include the following:

- In the NEAFC area, non-Contracting Party fishing vessels appearing to engage in IUU activities are placed on lists of concern. Investigations are made into vessels on the NEAFC's 'A list'; if there are no extenuating circumstances, the vessel is placed on the 'B list'. Vessels on the B list face severe restrictions on their activity in the NEAFC area, and potentially beyond (NEAFC, 2020).
- In the EU, Regulation 1005/2008, establishing a Community system to prevent, deter and eliminate illegal, unreported and unregulated fishing, came into force in 2010, to ensure that only fishery products certified as legal can be imported into or exported from the European Union.
- In the Arctic, a new agreement to prevent unregulated high-seas fisheries in the central Arctic Ocean was signed in 2018 by Arctic coastal states (Norway, Canada, Denmark, Russia and the United States), the EU, Iceland, China, Japan and the Republic of Korea. The parties will not allow their own vessels to fish in the international part of the central Arctic Ocean until international conservation and management measures have been established; this applies for an initial period of 16 years once the agreement comes into force and can be extended. Part of this area is already covered by NEAFC management measures (see NEAFC, 2018).

The use of Sustainability indices: The certification of fisheries highlights the sustainability credentials of a fishery and communicates that designation through the supply chain, including to consumers. The most widespread scheme is that operated by the Marine Stewardship Council (MSC). This takes account of the sustainability of fish stocks, environmental impacts, and effective fisheries management. For example, a fishery cannot be certified if it causes significant or long-term damage to seafloor habitats or other vulnerable marine ecosystems. According to MSC's annual report for 2018-19, the proportion of the total fishing catch in the North-East Atlantic that is MSC certified is in the range 40-60% (Marine Stewardship Council, 2020). Fisheries added to the MSC certification list and mentioned in recent reports include the Faroe Islands ling and tusk fishery, and the Russian red king crab fishery in the Barents Sea (Marine Stewardship Council, 2019a). Fisheries can also have their MSC certification suspended.

Marine aquaculture, Freshwater aquaculture, Agriculture and Forestry [Cultivation of living resources]:

Aquaculture is a driver of the status of fish populations: planktivorous fish are harvested and used to feed farmed fish. Disease and parasites are also issues of concern. Within the EU, Regulation EU 2016/429 of the European Parliament and of the Council of 9 March 2016 is concerned with transmissible animal diseases and amending and repealing certain acts in the area of animal health (Animal Health Law). It has superseded the Aquatic Animal Health Directive (2006/88/EC) and regulates animal health issues in aquaculture establishments in relation to certain species taken from the wild into captivity, as well as parasite control in farmed fish.

Regional differences

Fisheries represent the most significant impact on the status of fish communities across the OSPAR Maritime Area. Fisheries management has been implemented at national or regional scale in all OSPAR Regions, including in areas outside of national jurisdiction.

Additional human activities are focused more on coastal areas of the Greater North Sea and Celtic Seas, with potential for cumulative effects. The anticipated increase in offshore renewable energy development, particularly in the Greater North Sea, is likely to indirectly reduce the pressure from fishing activities in this region.

Gaps and opportunities

Are we doing enough?:

With the exception of some skates and rays, most of the OSPAR listed fish species are assessed as having poor status, and there are still gaps in the OSPAR MPA network for almost all of the fish species on the OSPAR List. The coverage is considered as being ecologically coherent for only houting, long-snouted seahorses, allis shad and salmon, among the species for which MPAs may be a useful management tool.

Fisheries management regulations have resulted in the harvesting of more fish stocks to levels considered sustainable, and a shift from fish stock management to an ecosystem perspective, including the introduction of measures to protect vulnerable habitats and species. However, concerns remain in relation to by-catch, the need to integrate concepts of ecosystem function into fisheries management regulation, such as the idea of trophic cascades, and how management regimes can take account of the impact of fisheries on the pelagic habitat and food webs. Further work to progress the alignment of fisheries management and environmental protection responses is also required.

Climate change has important implications for fish communities and stocks, including changes in recruitment and productivity and range shifts, with implications for management. The focus for these actions lies outside OSPAR's remit, but underlies all other responses.

Are there other types of responses that could be undertaken by OSPAR to improve the status of fish communities?

Two key objectives of the NEAES 2030 are particularly relevant. First, as a cross-cutting issue, OSPAR will initiate discussions on the development of a practical approach for regional-scale ecosystem-based management, including through the 'Collective Arrangement' and in cooperation with fisheries management bodies and other competent organisations, in order to strengthen ecosystem resilience to climate change and to safeguard the marine environment, its biodiversity and ecosystem services (SX.O2).

In addition, OSPAR will work with relevant competent authorities and other stakeholders to minimise, and where possible eliminate, incidental by-catch of marine mammals, birds, turtles and fish so that it does not represent a threat to the protection and conservation of these species and will work towards strengthening the evidence base concerning incidental by-catch by 2025 (S7.O6). This will give increased attention to the effects of incidental by-catch, including for protected fish species; OSPAR should take into consideration relevant by-catch studies conducted in the framework of OSPAR, the European Commission and ICES and their conclusions to come.

Other areas for potential OSPAR response could include:

- Progressing the work on understanding the management effectiveness of MPAs, and sharing experience and best practice on management actions that best achieve the conservation objectives as related to fish communities;
- Mitigation responses to support job changes in areas where the fishing industry has declined;
- Restoring certain habitats to produce co-benefits for some fish species. OSPAR Benthic Habitats Thematic Assessment;
- Studying the implications of removing fish from the wild (wrasse and lumpfish) for use as cleaner fish to manage parasite levels in farmed fish, including the genetic interaction of escaped cleaner fish; this has been identified by ICES as worthy of further investigation (ICES, 2020).

By-catch. © Shutterstock

Cumulative Effects

Cumulative effects assessment for fish

It should be noted that the Sankey plots and associated narratives in this thematic assessment are an illustrative representation of a complex set of interactions between DAPSIR components at the coarse North-East Atlantic scale and should be considered and interpreted alongside the supporting full thematic assessment narrative. The Sankey plots should thus be applied with caution and not considered or used as the sole basis for management decisions.

A range of human activities contribute pressures with the cumulative potential to affect the state of fish and associated ecosystem services (with consequences for societal drivers such as food, energy, space, health and biodiversity). Extraction, mortality and injury affecting wild species is the predominant pressure. Others include those from climate change (i.e., changes in temperature regimes, stratification and circulation patterns, acidification, nutrient enrichment, changes in water chemistry); input of other substances; input of litter; input of microbial pathogens; physical disturbance of the seabed; habitat loss; input of anthropogenic sound; changes to hydrological condition; input or spread of NIS; input of water and input of nutrients, but there is lower confidence in ranking their relative importance. Following a Driver-Activity-Pressure-State-Impact-Response (DAPSIR) framework and a weighting exercise, an indicative assessment of cumulative effects has been undertaken (see CEMP Guideline for details) as a first step to describing the potential pathways of cumulative causes and the consequences of change in the ecosystem, linking these to impacts on ecosystem services.

The current thematic assessment describes the connectivity between the relevant DAPSIR components. Sankey diagrams provide a schematic of potential impact pathways describing cumulative causes and consequences of change in the ecosystem, demonstrating that multiple human activities are contributing to multiple pressures which can lead to multiple impacts on the state of fish and associated ecosystem services (see CEMP Guideline for details). A better understanding of this complexity in the causes and consequences of cumulative effects from human activities on ecosystem state and ecosystem services is critical in order to explicitly apply the ecosystem approach to target management measures appropriately.

The evidence underpinning the analyses described in this section is drawn from the Driver, Activity, Pressure, State, Impact and Response sections of this thematic assessment, and should be read and interpreted alongside the extended narratives provided therein. The Human activities and Pressures sections of this thematic assessment provide detail of the threats that the left-hand side of the Sankey plot (**Figure CE.1**) pose to fish. The State section of this thematic assessment provides details of ecosystem state, shown in the centre of the Sankey plot (**Figure CE.1**), illustrated for fish. The right-hand side of **Figure CE.1** incorporates the impact on ecosystem service scores to present the Activity, Pressure, State and Impact components of the fish 'ecosystem' in a single plot. This is consistent with NEAES operational objective S7.O3 on ecosystem services and natural capital, "to recognise, assess and consistently account for human activities and their consequences in the implementation of ecosystem-based management."

Figure CE.1 shows the complex combinations of human activities and pressures on state changes (left-hand side) and those of state changes on ecosystem services (right-hand side). However, there is currently insufficient understanding and evidence to be able to directly track from left to right, hence the single bar in the centre. This should be a focus of future assessments.

Overall, confidence in the evidence for the weighted bow tie analysis outputs presented in the Fish Thematic Assessment is described as **medium for evidence** and **medium/low for degree of agreement**. Additionally, separate confidence assessments have been applied to each module.

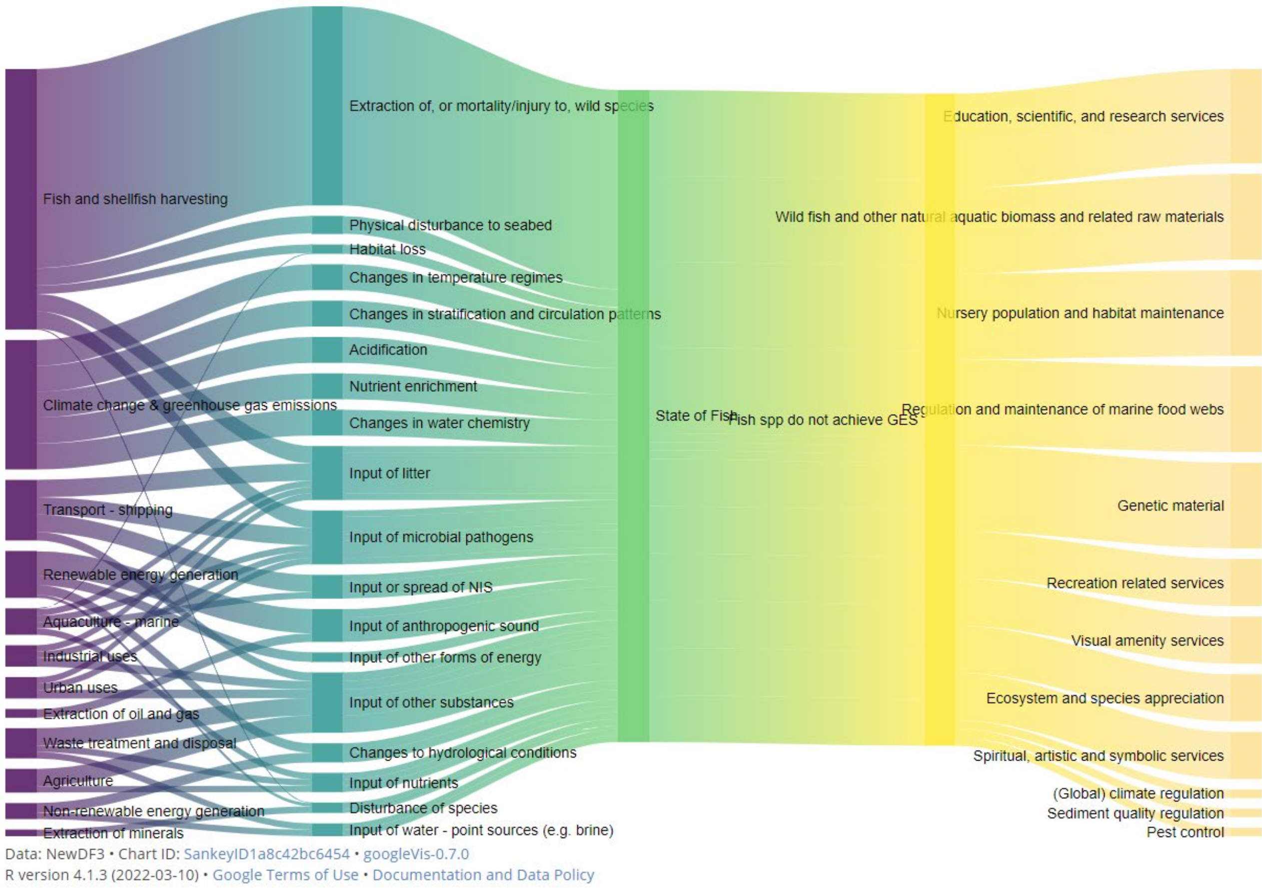


Figure CE.1: Impact Potential of Fish to exposure to pressures from human activities in the North-East Atlantic. Columns left to right: Activity, Pressure, State, Environmental Impact, Ecosystem Service. Derived from Exposure score (Extent x Frequency of pressure) x Degree of Impact score (in terms of whether impact is Acute or Chronic). Pressures with a low Degree of Impact score have been removed for clarity. 'Impact' in this context does not consider the persistence of the pressure or the resilience of the ecosystem associated with that pressure. Were these parameters to be included, the relative contribution for some pressures would most likely increase and score higher in the relative ranking. Links are weighted to indicate relative contribution to impact. A wider link = greater potential for impact

It should be noted that the Sankey plots and associated narratives in this thematic assessment are an illustrative representation of a complex set of interactions between DAPSIR components at the coarse North-East Atlantic scale and should be considered and interpreted alongside the supporting full thematic assessment narrative. The Sankey plots should thus be applied with caution and not considered or used as the sole basis for management decisions.

Figure CE.1 demonstrates the complex relationships which the collective pressures from human activities have on the quality status of fish. This complexity suggests that while single-issue responses may be effective, in order to fully apply ecosystem-based management OSPAR needs to consider the causes and consequences of changes in ecosystem state more holistically,

- recognising that any measures to reduce impacts, while critical to ecosystem health, could have potential consequences for the ability to maintain ecosystem services to meet society's needs, which in turn has consequences for the viability of human activities in the North-East Atlantic; and
- recognising that pressures may have additive, multiplicative, synergistic or antagonistic interactions when combined, which has implications for the nature of the threats posed to fish and how best to manage those threats.

Methodology

A modified bow-tie analysis (Cormier *et al*., 2018; Cormier *et al*., 2019) was developed to identify and connect all the DAPSIR components, integratsing these into either a pressure-focused (e.g., underwater sound, litter, hazardous substances, eutrophication) or a biodiversity receptor focused (e.g., pelagic habitats, benthic habitats, fish, marine birds, marine mammals) analysis of the causes and consequences of change. For the biodiversity assessments, the APS connections are weighted to determine the most important, using an adaptation of the ODEMM pressure assessment (Robinson *et al*., 2013; Knights *et al*., 2015) focusing on:

1. **Exposure module:** spatial extent and frequency for all activity pressure combinations on state, to generate exposure weightings;
2. **Impact potential module:** spatial extent, frequency of occurrence and impact potential for all activity pressure combinations on state, to generate impact potential weightings;
3. **Risk module:** spatial extent, frequency of occurrence, impact potential for all activity pressure combinations on state, combined with pressure persistence and ecosystem resilience, to generate risk weightings.

The SI (ecosystem services) connections are weighted to determine which are the most important (Cornaccia, 2022).

The impact potential and ecosystem services outputs are combined and presented in Sankey diagrams (**Figure CE.1**).

Confidence in this weighted bow-tie analysis exercise for fish has been assessed in accordance with the QSR 2023 guidance. Confidence is based on two criteria to communicate the degree of uncertainty in the key findings: (i) level of evidence (determined by considering the type, amount, quality, and consistency of evidence, i.e., robust, medium, or limited) and (ii) degree of agreement (i.e., high, medium or low).

Exposure module

Confidence Assessment: Evidence – Medium; Consensus – Medium

Pressures from human activities have been demonstrated in the assessments for this QSR to be widely distributed in the OSPAR Maritime Area. The presence of pressures does not automatically lead to adverse impacts. However, in the first instance consideration of the spatial and temporal extents of pressures provides a useful basis for the consideration of cumulative effects within a risk-based approach (in line with the North-East Atlantic ecosystem principle and strategic approach).

The exposure module describes the extent of the pressure from human activities in the North-East Atlantic. It considers the spatial extent and frequency of the human activity pressure combinations which have been identified as important for fish (derived from spatial extent score multiplied by frequency score). Exposure relates only to the pressure cell in the DAPSIR schema (**Figure CE.1**). The consideration of exposure in isolation provides a coarse cross-cutting assessment, providing an early identification which allows OSPAR to develop management strategies for pressures in order to prevent / minimise impacts.

The thematic assessments for Hazardous Substances, Eutrophication, Marine Litter, Underwater Noise, Offshore Industry, Climate Change and the Ocean Acidification Other Assessment describe pressures on fish. The Radioactive Substances Thematic Assessment identifies inputs of radionuclides from a range of human activities but has concluded that there are no significant radiological impacts on biodiversity from the current levels of radionuclides.

Climate Change and Ocean Acidification pressures have been identified as important for fish.

Input of substances, input of litter, input of microbial pathogens, anthropogenic sound, input of radionuclides and disturbance of species are also important and their exposure scores are among the highest, demonstrating the ubiquitous nature of these pressures in the North-East Atlantic. Extraction of species, physical disturbance of the seabed, habitat loss, and input of other forms of energy also have high exposure scores.

The exposure scores support the importance that OSPAR places on these pressures in its North-East Atlantic Environment Strategy 2030,

- Strategic Objective 2 on preventing pollution by hazardous substances, and the work of the Hazardous Substances and Eutrophication Committee (Hazardous Substances Thematic Assessment)
- Strategic Objective 3 on preventing pollution by radioactive substances, and the work of the Radioactive Substances Committee (Radioactive Substances Thematic Assessment).
- Strategic Objective 4 on preventing inputs and significantly reducing marine litter (Marine Litter Thematic Assessment) and the work of the Environmental Impacts of Human Activities Committee (Human Activities Thematic Assessment)
- Strategic Objective 5 on protecting and conserving marine biodiversity and ecosystems (this Fish thematic assessment, and the work of the Biodiversity Committee including the other biodiversity thematic assessments (Pelagic Habitats Thematic Assessment) (Benthic Habitats Thematic Assessment) (Marine Mammals Thematic Assessment) (Marine Birds Thematic Assessment) (Food Webs Thematic Assessment).
- Strategic Objective 8 on reducing anthropogenic underwater noise (Underwater Noise Thematic Assessment), and the work of the Environmental Impacts of Human Activities Committee (Human Activities Thematic Assessment)
- Strategic Objective 9 on safeguarding the structure and functions of the seabed/marine ecosystems by preventing significant habitat loss and physical disturbance (this fish thematic assessment, and the work of the Biodiversity Committee including the Benthic Habitats Thematic Assessment.

Multiple human activities have been identified as exerting these pressures in the North-East Atlantic. Any actions to manage these pressures in order to prevent or reduce impacts on state, either individually or cumulatively (collectively), will need to consider if and how these human activities might best be targeted (and the consequences for the associated drivers and ecosystem services) within an Ecosystem Approach.

Impact potential module:

Confidence Assessment: Evidence – Medium; Consensus – Medium/Low

Impact potential is incorporated with the exposure module (spatial extent and frequency) for pressures from specified human activities (derived from the aggregated exposure score multiplied by the degree of impact score). Impact potential here relates to generic interaction in terms of a pressure's likely effects on the ecological component, in the categories of: low potential for significant impact, chronic impact or acute impact (Robinson *et al*., 2013). **Figure CE.1** shows the combined weighted scores for exposure and impact potential.

Any activity-pressure combination with a Degree of Impact score of Low was filtered out, following discussion with the expert group. For example, the input of radionuclides has been filtered out based on the conclusions in the Radioactive Substances Thematic Assessment as these have been demonstrated to have low potential for significant impact based on the available evidence. Other pressures filtered out as having low potential for significant impact are changes to hydrological conditions from fishing activities; disturbance of species from coastal and flood protection; extraction of oil and gas, non-renewable energy generation; tourism and leisure activities and infrastructure, transport – shipping; habitat loss from aquaculture – freshwater, navigation dredging, coast and flood protection, land claim, tourism and leisure infrastructure, transport infrastructure; anthropogenic sound from renewable energy generation and transport – shipping; marine litter from tourism and leisure activities; microbial pathogens from tourism and leisure activities; nutrients from extraction of minerals and oil and gas, forestry, industrial uses; input of other forms of energy from extraction of oil and gas; input of other substances from extraction of minerals and oil and gas, transport – land; and physical disturbance of the seabed from subsea cables.

The relative ranking of pressures changes when impact is considered (**Figure CE.1**). Fish mortality and injury associated with fisheries activities is ranked highest. Climate change pressures also rank highly (see the Climate Change Thematic Assessment for detail on contributing human activities). The Pressures section of this thematic assessment describes the importance of pressures to fish and corroborates the importance of fish mortality and injury and climate change pressures. While the weighted bow-tie analysis has identified relative rankings for other pressures, the OSPAR Fish Expert Group considers that limited evidence exists to confirm these relative rankings. It is thus concluded that the other pressures shown in **Figure CE.1** should be considered of equal importance until further evidence can be provided (e.g., input of substances, input of litter, input of microbial pathogens, anthropogenic sound and disturbance of species).

Risk module:
Confidence Assessment: Evidence – Low; Consensus – Low

Given the low confidence scoring, the outputs from the risk analyses have not been included in this thematic assessment for QSR 2023. However, it is beneficial to consider the agreed outputs of the persistence weightings. Details of the criteria applied in the risk module are described in the CEMP Guideline.

Regional summary of likely cumulative effects

Confidence Assessment: Evidence – High; Consensus – Medium.

While the weighted bow-tie analyses displayed in the Sankey diagrams have been produced at the North-East Atlantic scale, consideration can be given to where regional differences may arise by cross-referencing other assessments in QSR 2023.

The Fish Thematic Assessment identifies the cumulative pressures for fish (but no regional breakdown of pressures was attempted there) in terms of both exposure and impact.

The list below summarises the main pressures impacting fish, with information on associated activities. Note that activity-pressure combinations scored as low-impact on the basis of current available evidence were filtered out from the Sankey diagram in **Figure CE.1**. However, the activity-pressure links listed below relate to the unfiltered outputs used in the Exposure assessment.

- Climate change and ocean acidification pressures;
- Extraction of, or mortality to, wild species from fish and shellfish harvesting;
- Physical disturbance of the seabed from renewable energy generation; extraction of oil and gas; restructuring of seabed morphology; transmission of electricity and communications; fish and shellfish harvesting;
- Disturbance of species from renewable energy generation; extraction of oil and gas; non-renewable energy generation (Nuclear); extraction of minerals; transport – shipping; tourism and leisure activities and infrastructure; fish and shellfish harvesting;
- Input of other substances from research, survey and educational activities; transport – land; military operations; extraction of oil and gas; waste water treatment and disposal; non-renewable energy generation (Nuclear); transport – shipping; urban uses and industrial uses;
- Input of anthropogenic sound from renewable energy generation; extraction of oil and gas and transport – shipping;
- Input of nutrients from industrial uses; agriculture and forestry;
- Habitat loss from tourism and leisure infrastructure; aquaculture – marine; aquaculture – freshwater; canalisation and other water course modification; coastal protection and flood defence; land claim; transport infrastructure;
- Input of microbial pathogens from transport – shipping; urban uses; industrial uses; tourism and leisure activities; fish and shellfish harvesting; aquaculture – marine;
- Input or spread of NIS from transport – shipping; aquaculture – marine;
- Input of other forms of energy from extraction of oil and gas and non-renewable energy generation (nuclear);
- Input of water from waste water treatment and disposal and non-renewable energy generation (nuclear);
- Changes in hydrological conditions from non-renewable energy generation (nuclear); fish and shellfish harvesting;
- Input of litter from transport – shipping; urban uses; industrial uses; tourism and leisure activities; fish and shellfish harvesting; aquaculture – marine.

OSPAR does not have evidence on all human activities, but the regional breakdown of relative intensities for the activities Agriculture; Aquaculture; Extraction of minerals (aggregates); Oil and Gas; Nuclear; Renewable Energy; Fisheries and Shipping have been extracted from the supporting evidence for QSR 2023 and are summarised below. The direct influence of the cumulative pressures from these activities on fish is likely to follow similar trends in intensity within these Regions. Pressures spread beyond the spatial extent of these human activities, but insufficient evidence is currently available, and consequently trends in indirect cumulative pressures have not been considered.

The Offshore Industry Thematic Assessment describes:

- low relative intensity of Oil and Gas sector activity in the Bay of Biscay and Iberian Coast (Region IV) and Wider Atlantic (Region V);
- moderate relative intensity of Oil and Gas sector activity in Arctic Waters (Region I) and Celtic Seas (Region III);
- high relative intensity of Oil and Gas sector activity in the Greater North Sea (Region II).

The Human Activities Thematic Assessment describes:

- low relative intensity of Aggregate Extraction sector activity in Arctic Waters (Region I) and the Wider Atlantic (Region V);
- moderate relative intensity of Aggregate Extraction sector activity in the Celtic Seas (Region III) and Bay of Biscay and Iberian Coast (Region IV);
- high relative intensity of Aggregate Extraction sector activity in the Greater North Sea (Region II);
- moderate relative intensity of Agriculture sector activity in the Celtic Seas (Region III) and Bay of Biscay and Iberian Coast (Region IV);
- high relative intensity of Agriculture sector activity in the Greater North Sea (Region II);
- low relative intensity of Aquaculture sector activity in the Wider Atlantic (Region V);
- moderate relative intensity of Aquaculture sector activity in the Celtic Seas (Region III) and Bay of Biscay and Iberian Coast (Region IV);
- high relative intensity of Aquaculture sector activity in Arctic Waters (Region I) and the Greater North Sea (Region II);
- low relative intensity of Fisheries sector activity in the Wider Atlantic (Region V);
- moderate relative intensity of Fisheries sector activity in the Bay of Biscay and Iberian Coast (Region IV);
- high relative intensity of Fisheries sector activity in Arctic Waters (Region I), the Greater North Sea (Region II) and Celtic Seas (Region III);
- low relative intensity of Offshore Renewable Energy sector activity in the Bay of Biscay and Iberian Coast (Region IV);
- moderate relative intensity of Offshore Renewable Energy sector activity in the Celtic Seas (Region III);
- high relative intensity of Offshore Renewable Energy sector activity in the Greater North Sea (Region II);
- low relative intensity of Tourism sector activity in Arctic Waters (Region I) and the Wider Atlantic (Region V);
- moderate relative intensity of Tourism sector activity in the Celtic Seas (Region III);
- high relative intensity of Tourism sector activity in the Greater North Sea (Region II) and Bay of Biscay and Iberian Coast (Region IV);
- low relative intensity of Transport and Shipping sector activity in the Wider Atlantic (Region V);
- moderate relative intensity of Transport and Shipping sector activity in Arctic Waters (Region I);
- high relative intensity of Transport and Shipping sector activity in the Greater North Sea (Region II), Celtic Seas (Region III) and Bay of Biscay and Iberian Coast (Region IV).

The Radioactive Substances Thematic Assessment describes:

- no Nuclear sector activity in the Wider Atlantic (Region V);
- low relative intensity of Nuclear sector activity in Arctic Waters (Region I);
- moderate relative intensity of Nuclear sector activity in the Bay of Biscay and Iberian Coast (Region IV);
- high relative intensity of Nuclear sector activity in the Greater North Sea (Region II) and Celtic Seas (Region III).

Regional evidence for trends in the intensity of other human activities or for climate change and ocean acidification was not available in sufficient detail to be utilised in this assessment.

Climate Change

Climate change effects on marine fish

- The previously documented climate change impacts on fish include changes to species distributions, body size, phenology, recruitment and fish biomass.

- General trends of ocean warming impacts include distributional shifts towards northern ranges of fish distributions; larger species decreasing in body size while smaller fish may more readily adapt to the environment; earlier spawning; and changes in fish biomass which may be reflected through geographic changes in catch.
- Climate change impacts act in tandem with other factors (density dependence, trophic interactions) and are difficult to disentangle from these.
- Most research on the impacts of climate change on fish has focused on ocean warming. The impacts of other environmental changes associated with emissions of greenhouse gases (e.g., ocean acidification, sea ice changes) will be revealed as further research is done.

The climate-associated changes in oceans projected by global models include rising sea temperatures and changes to primary production. Warming in the North Atlantic is expected to continue, with the greatest warming predicted for the Atlantic-Arctic including the Barents Sea and Greenland Seas (Peck and Pinnegar, 2018). Models also indicate an overall decline in primary productivity for much of the North-East Atlantic, but a moderate increase in the Atlantic-Arctic (Peck and Pinnegar, 2018). Both of these developments have been linked to changes in the distribution of fish species. The research on temperature-related shifts in marine fish has been active for more than a decade (Perry *et al.*, 2005; Poloczanska *et al.*, 2013). Recent assessments of the long-term distributional shifts of key commercial fish stocks in Europe find distributional shifts for all examined species, the main drivers of which are environmental conditions, principally temperature (Baudron *et al.*, 2020; ICES 2016). Species identified as 'big movers' with distributional shifts associated with global warming included anchovy (expansion of population in North Sea); white anglerfish (increase in Iceland, increase abundance in northern North Sea); cod (northward expansion in Barents Sea, northward movement in North Sea); megrim (*L. boscii* northward shift in North Sea, *L. whiffiagonis* negatively correlated to temperature in Spain); haddock (decreased occurrence in southern North Sea); hake (increased abundance in northern North Sea); and plaice (abundance decline in bay of Biscay due to temperature effect on juvenile habitat) (ICES 2016). The westward and north-westward distributional changes of the North-east Atlantic mackerel (*Scomber scombrus*) have been linked to ambient temperature and mesozooplankton density (Olafsdottir *et al.*, 2019).

The role of temperature in distributional changes is difficult to disentangle from other factors such as the role of stock size. Temperature may affect the expansion or contraction of a species due to changes in habitat suitability or recruitment rate (due to effects on physiology, survival, or impacts on planktonic life stages or planktonic prey), and stock size may enhance or counteract these effects through its role in density-dependent habitat use (Baudron *et al.*, 2020). Distributional shifts are not only reflected geographically but also in terms of water depth. In European shelf seas, where bottom temperatures have experienced 1,6°C increases between 1980 and 2004, a deepening response of demersal fish such as cod, megrim and anglerfish has been noted (Dulvy *et* al., 2008) and the availability of suitable habitat at increasing depth may limit species range shifts under future climate scenarios (Rutterford *et al.*, 2015). Food web interactions also play a role in species range shifts. Predictions of species range shifts have the potential to overestimate range shifts if food web interactions and allometry are ignored. Models show slower range shifts for species experiencing dynamic trophic interactions than for single species (Tekwa *et al.*, 2022).

The average body size of marine organisms is projected to shrink under ocean warming as a result of direct impact, and as an adaptive response, with small-bodied pelagic fish being possibly more resilient to climate change (Lefort *et al.*, 2015). Indeed, in fish assemblages in the western English Channel, larger species (rays, hake and anglerfish) have decreased significantly in both mean body size and abundance over the last century, while smaller fish species (mainly flatfish and gobies) have increased in abundance (Genner *et al*., 2010). Similar trends have been observed in the same species in the Celtic Seas (Pinnegar *et al*., 2002). Within species, changes in size-at-age across lifespan are expected to differ, with juvenile fish growing more rapidly due to the ecophysiological effects of temperature and adult maximum sizes being reduced for metabolic reasons (Ikpewe *et al*., 2021). In general, long-term data series have shown how smaller fish species might be able to quickly respond to the thermal environment due to their life history traits, while larger fish species' observed decline in abundance and size could be caused by co-occurring warming and size-selective overharvesting (Genner *et al*., 2010; Pecuchet *et al.*, 2017; Beukhof *et al*., 2019). Conversely, under reduced fishing pressure, increases in the abundance of long-lived species with slower life-history strategies have been observed in the southern North Sea, despite increasing temperatures in recent decades (Murgier *et al.,* 2021).

Herring populations in the Celtic Seas and north-west of Ireland have seen a steady decline in size-at-age over the last few decades. Growth of this pelagic fish has been shown to be impacted by warming conditions, and it is hypothesised that at the southern limit of the distribution range, herring might be more susceptible to climate warming compared with northerly populations (Lyashevska *et al*., 2020). The opposite has been observed for herring populations located at the northern edge of the distribution range. Norwegian spring-spawning herring's recruitment, body size and spawning stock biomass (SSB) are positively correlated with temperature (Graham and Harrod, 2009). For other fish, such as cod and haddock, at the northern distributional range the warmer years are leading to earlier spawning, and with high levels of food available juveniles reach a larger size earlier in the year, increasing the survival rate during the subsequent winter months (Ottersen, 2000). Cold-water species, like arctic and boreal fish, are predicted to be particularly impacted (Poloczanska *et al*., 2013) by the warming climate. The wolffish *Anarhichas lupus* in the North-East Atlantic, caught as by-catch in mixed fisheries in the North Sea, has been declining in abundance and has also been shown to be experiencing a change in size distribution (Bluemel *et al*., 2022).

Climate change is expected to have an important impact on fish biomass, with the global catch redistributed by 2055. Models predict an increase of maximum catch potential (the maximum exploitable catch of a species assuming the geographic range and fisheries selectivity do not change) in high latitude regions and poleward tips of the continental shelf margin, and declines within the tropics and at the southern margins of semi-enclosed bodies of water (Cheung *et al*., 2010). Under this scenario, the Arctic and sub-Arctic region would see an increase in maximum catch potential, while north-west European shelf areas (Celtic Seas and North Sea) and the Bay of Biscay would experience a decrease (Cheung *et al*., 2010). Nevertheless, the increased ice melting rate and freshwater input in the boreal region will also increase stratification, which in turn will hinder the nutrient supply from the deeper layers, hence limiting primary production (Lefort *et al*., 2015).

Traditionally, stock assessment approaches assume that abiotic conditions are constant. However, climate change has been identified as a stressor that has already effectively reduced MSY for many important stocks globally (Bryndum-Buchholz *et al*., 2021). Accordingly, different OSPAR Regions are expected to be impacted in different ways: the North-East Atlantic has already seen dramatic changes in sea surface temperature which have caused changes not just in distribution, but also in abundance. Fish biomass in the Arctic is expected to change due to fast warming and freshening (Drinkwater, 2005). These new conditions may reduce reproductive capacity, thus making certain stocks vulnerable to fishing levels that were previously considered sustainable (Brander and Mohn, 2004), but in other cases a positive effect on fish biomass may be observed (Arctic Council, 2005).

The response of the Atlantic cod *Gadus morhua* to climate change has been the subject of many investigations due to its commercial importance. The recruitment of different Atlantic cod stocks has been impacted by climate (Graham and Harrod, 2009), particularly at the edge of its geographical range (positive in cold-water stocks and negative in warm-water stocks) (Planque and Frédou, 1999). In general, all cod stocks will be impacted, albeit differently, by climate change, especially by temperature during the spawning season, with negative effects in the populations at the warmer edges of the distribution, and positive ones in the lower thermal range (Mantzouni and MacKenzie, 2010; Núnez-Riboni *et al.*, 2019). The potential for incorporating association with sea temperatures during spawning season into stock forecasts has recently been demonstrated for gadoid stocks (cod *Gadus morhua* and whiting *merlangus merlangius*) in the Irish Sea region (Bentley et al., 2021) and incorporated into the ICES advice scenarios for cod *Gadus morhua* in the Irish Sea in 2022 (i.e., via F_{ECO} reference points; ICES, 2022).

Other climate change impacts and concluding statements

The most frequently studied climate change impacts are discussed above, but the suite of climate associated changes is broader (e.g., including changes in sea ice, salinity, and oxygen; coastal erosion; and extreme events) and the list of impacts on fish has the potential to expand as more research is done. The impacts of ocean acidification on fish are less often studied but may impact early life stages (Pimentel *et al.*, 2016). Biogeographic shifts in zooplankton in response to warming are documented but other factors such as changing salinity may also impact zooplankton abundance or community composition (Wells *et al.*, 2022). Impacts may also be cumulative, as when environmental impacts (changes in temperature, salinity, pH, oxygen) interact with other biological changes/interactions (e.g., density dependence, food web interactions). Ocean changes that lead to altered timing of primary production (Hjerne *et al.*, 2019; Mészáros *et al.*, 2021) may act in tandem with the impact of ocean warming on fish phenology (i.e., change in timing of spawning, larval hatching or migration), leading to mismatches between first-feeding fish larvae and their prey (Neuhemier *et al.*, 2018). For example, research from the North Sea reveals that temperatures affect the match between the hatch time of the sandeel (*Ammodytes marinus*) and the egg production of its copepod prey. The specific cause is the rate of seasonal temperature decline between autumn and winter that is related to sandeel gonad and egg development, while February temperatures relate to the timing of copepod presence. Thus, the interplay of these two temperature relationships affects the trophic match between sandeel and their prey (Regnier *et al.*, 2019). In Atlantic cod, another North Sea species with temperature-dependent gonadal development, research suggests that rising sea temperature has led to a shift in spawning phenology (McQueen and Marshall, 2017). With environmental conditions expected to change drastically in the next two decades (IPCC, 2022), impacting fish in various different ways, estimates of fishing reference points under average, constant climate conditions might become obsolete (Travers-Trolet *et al.*, 2020) and novel approaches will be required in order to incorporate ecosystem-driven changes in stock biomass into current fisheries advice frameworks (Howell *et al.*, 2021; Bentley *et al.*, 2021).

Fish populations will also be expected to experience indirect impacts of climate change, through impacts on fisheries. In addition to the obvious changes to fish and fisheries outlined above, future efforts to reduce greenhouse gas emissions might cause fishery displacement as a consequence of changes to the gear or technology used. Good fisheries management will support resilience in exploited fish species. Hence, robust, science-based management plans will be crucial to ensuring the adaptive capacity of fish throughout the OSPAR Maritime Area.

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Thematic Metadata

Field	Explanation
Data Source	The data used in this work were obtained from the following sources and explained in the CEMP guideline. Link to FC1 ICES Stock Information Database https://sid.ices.dk/Default.aspx ICES standard graphs database https://standardgraphs.ices.dk/stockList.aspx International Commission for the Conservation of Atlantic Tunas. 2016. Report of the Standing Committee On Research and Statistics (SCRS). https://www.iccat.int/Documents/Meetings/Docs/2016_SCRS_ENG.pdf International Commission for the Conservation of Atlantic Tunas. 2018a. Report for biennial period, 2016-17 PART II (2017) - Vol. 2 English version SCRS. https://www.iccat.int/Documents/BienRep/REP_EN_16-17_II-2.pdf International Commission for the Conservation of Atlantic Tunas. 2018b. Report for biennial period, 2018-19 PART I (2018) - Vol. 2 English version SCRS. https://www.iccat.int/Documents/BienRep/REP_EN_18-19_I-2.pdf International Commission for the Conservation of Atlantic Tunas. 2020. 2020a. SCRS Advice to the Commission. https://www.iccat.int/Documents/SCRS/SCRS_2020_Advice_ENG.pdf International Commission for the Conservation of Atlantic Tunas. 2020b. Report for biennial period, 2018-19 PART II (2019) - Vol. 2 English version SCRS. https://www.iccat.int/Documents/BienRep/REP_EN_18-19_II-2.pdf International Commission for the Conservation of Atlantic Tunas. 2022. Report for biennial period, 2020-21 PART II (2021) - Vol. 2 English version SCRS. https://www.iccat.int/Documents/BienRep/REP_EN_20-21_II-2.pdf
Relevant OSPAR Documentation	CEMP Guideline for Fish Thematic Assessment Integration Method (Agreement 2023-06)

OSPAR's Quality Status Report 2023

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Our vision is a clean, healthy and biologically diverse North-East Atlantic Ocean, which is productive, used sustainably and resilient to climate change and ocean acidification.

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