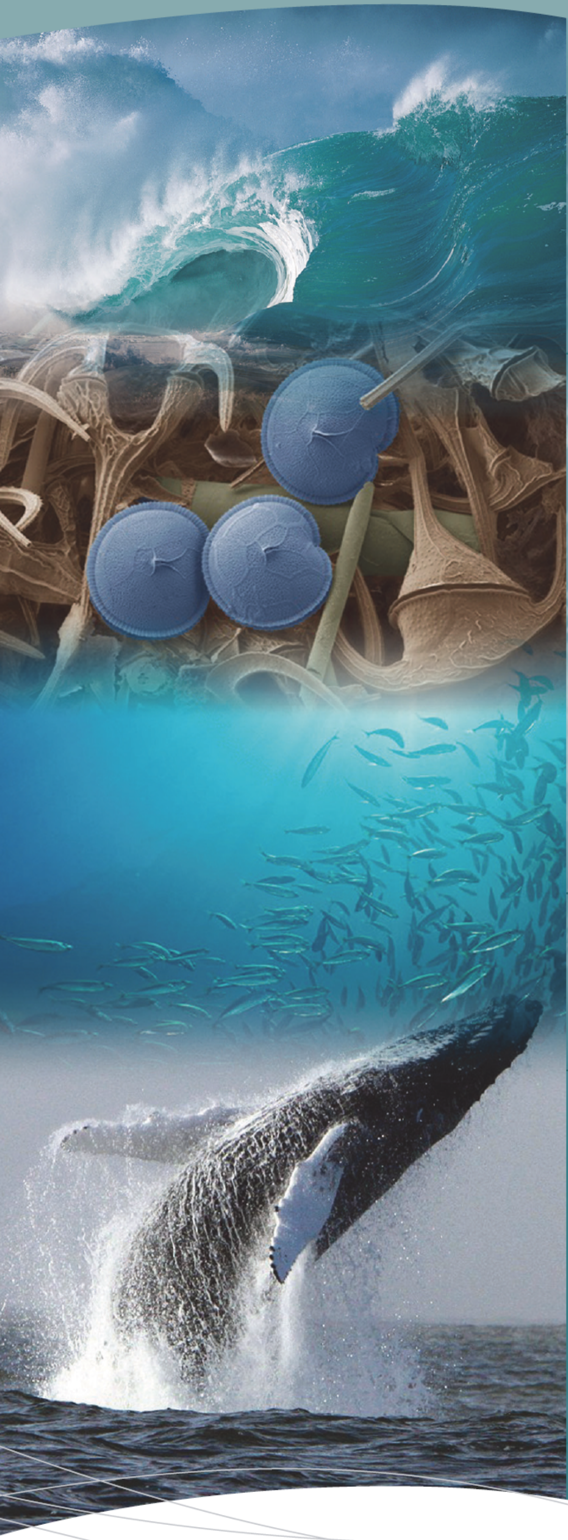
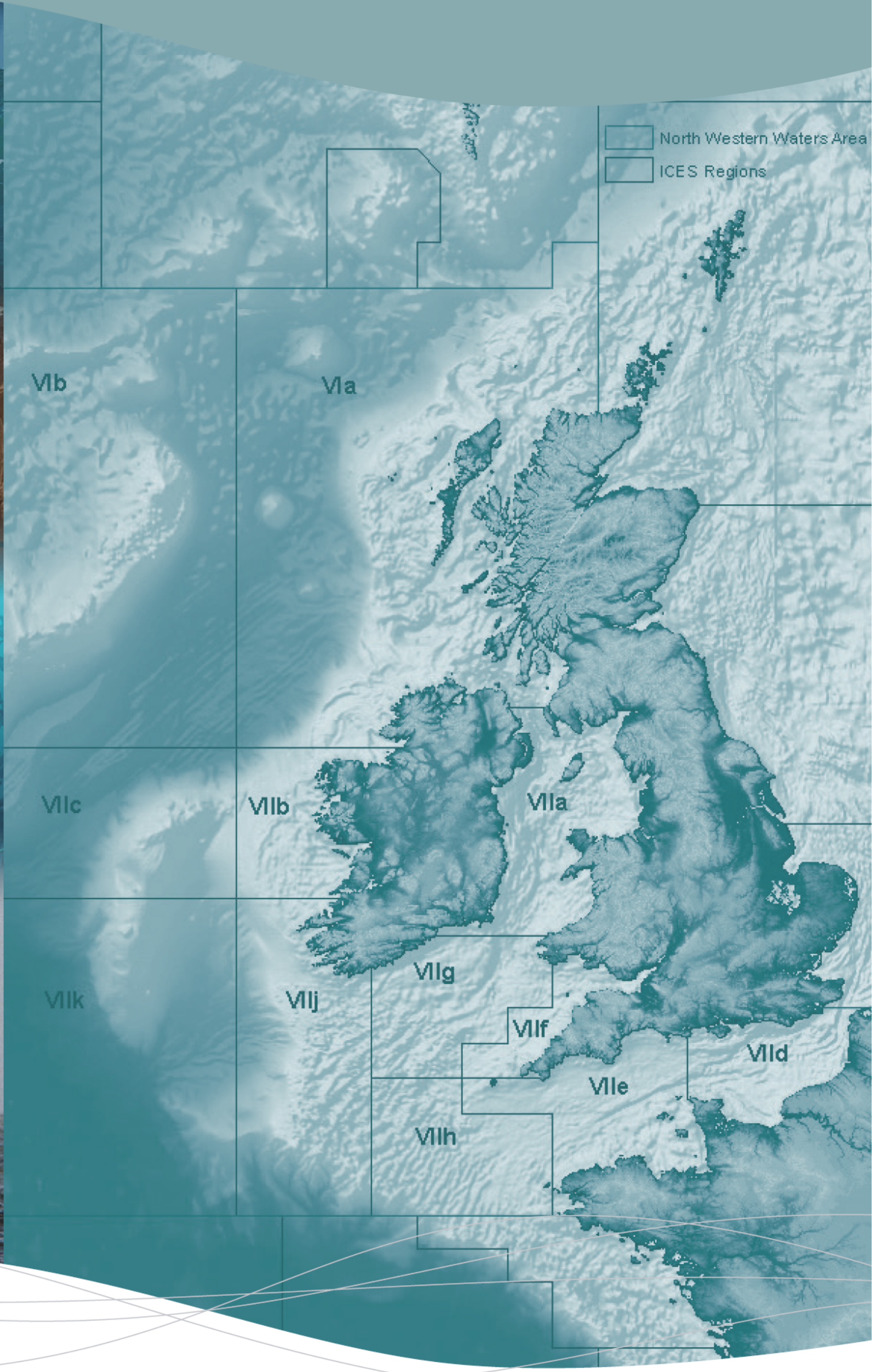
NORTH WESTERN WATERS ATLAS





Marine Institute
Foras na Mara

Conseil Consultatif pour les Eaux Occidentales Septentrionales
North Western Waters Advisory Council
Consejo Consultivo para las Aguas Noroccidentales

3rd Edition - April 2015

North Western Waters

ATLAS

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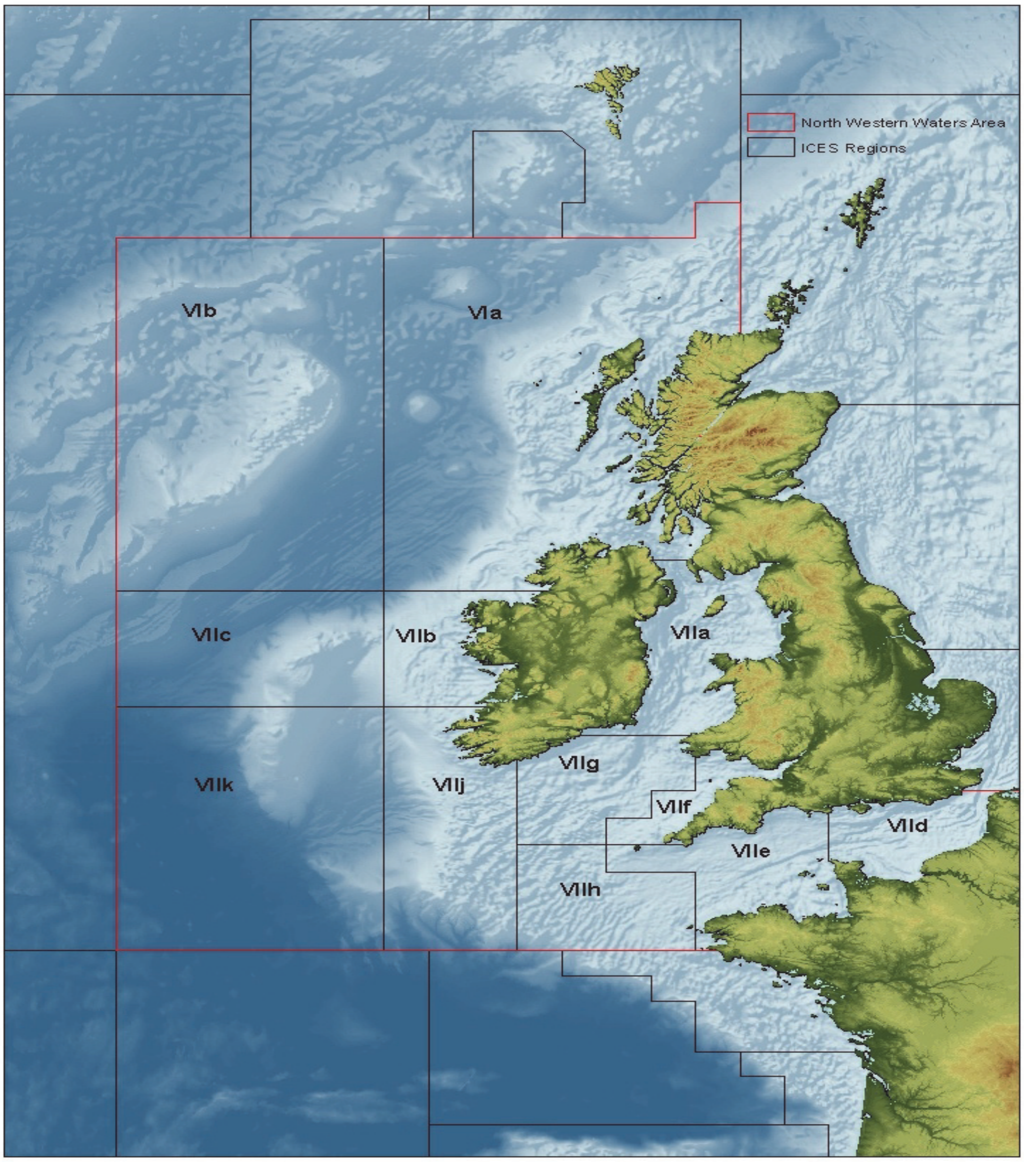

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Every effort has been made to ensure the accuracy of the information contained in this atlas. However the size of the document means that much of the detail has had to be omitted and some simplifications have been made for the sake of clarity.

Please cite this document as:
Dransfeld, L., Maxwell, H.W., Moriarty, M., Nolan, C., Kelly, E., Pedreschi, D., Slattery, N., and Connolly, P. (2014): *North Western Waters Atlas 3rd Edition*. Marine Institute.
ISBN 978-1-902895-59-8

Preface

Welcome to the third edition of the North Western Waters (NWW) Atlas, a joint publication between the Marine Institute and the NWW Advisory Council. This Atlas is intended for policy makers, managers and interested stakeholders and aims to provide a broad overview of the ecosystem of the NWW Advisory Council (AC) area. We have tried to make the science as clear and concise as possible, and keep technical language to a minimum. The information has been presented through a blend of text, tables, figures and images. There is a glossary of terms and a list of more detailed scientific references for those interested in following up certain issues.

The first and second editions of the Atlas, published in 2009 and 2011 respectively under the MEFEPO project, were extremely well received and this new edition has been modified in response to stakeholder feedback to provide updated information on the physical and chemical features, habitat types, biological features, birds, mammals, fishing activity and other human activities taking place within the NWW region. We have received valuable contributions from non-governmental organisations, which use citizen science to collect information on the marine ecosystem around us. Whenever citizen science is used to complement the existing knowledge, this is clearly marked in the relevant sections.

We welcome any feedback; please forward any comments to leonie.dransfeld@marine.ie.

Acknowledgements

Many people provided advice, suggestions and material for the three editions of the North Western Waters Atlas. Material for this edition was received from BirdWatch Ireland, Coastwatch Ireland, the Irish Environmental Protection Agency (EPA), National Parks and Wildlife Service Ireland (NPWS), Purse Search Ireland, the Irish Seal Sanctuary and the Irish Whale and Dolphin group. Sinead Cummins, Karin Dubsky, Siobhan Egan, Steven Newton, Sarah Varian, David Wall and Johnny Woodlock are particularly thanked for valuable feedback. We are also grateful to Margot Cronin, Hans Gerritsen, Colm Lordan, Kieran Lyons, Evin McGovern, David O'Sullivan, Joe Silke and David Stokes from the Marine Institute, Oliver Ó Cadhla from NPWS and Shane O'Boyle from the EPA who provided material and advice on various sections of the Atlas. Ryan McKenna designed the 3rd Edition's Atlas' Cover and Back.

The International Council for the Exploration of the Seas (ICES) and the Oslo Paris Commission (OSPAR) literature, datasets and data products were a rich source of information. We acknowledge this input as the work of an extensive scientific community.

Photographs and images throughout this publication are courtesy of the Marine Institute and/or the following photographers:

NASA image is courtesy of Jeff Schmaltz, MODIS Land Rapid Response Team at NASA GSFC

Additional photographs have been sourced by SuperStock images.

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SUMMARY

The North Western Waters (NWW) area is situated in the north east Atlantic off the west coast of Ireland and Scotland, and extends into the Celtic Sea, Irish Sea and the English Channel. The NWW covers approximately 1.15 million km^2 and comprises of twelve ICES Divisions and three OSPAR regions. Parts of the EEZ (Exclusive Economic Zone) of three countries (UK, Ireland and France) make up NWW.

The dominant seabed feature of the western part of NWW area is the Rockall Trough. This opens into the Porcupine Abyssal plane at its southern end and further south is the Porcupine Seabight. Eastward of these seabed features lies the continental slope and shelf. The shelf area comprises the semi enclosed Irish Sea, the Celtic Sea off the south coast of Ireland and the English Channel between France and the UK.

The main ocean current affecting the NWW area is the Gulf Stream System that draws warm water up from the Gulf of Mexico to the north east Atlantic via the North Atlantic current. In the north Atlantic, the system of warm water travelling north, losing its heat, sinking and merging with southbound cold currents is part of the Global Conveyor Belt (GCB). Water circulation in the shallow seas of the NWW is controlled by tides, density differences and winds and includes the shelf-edge current along the European shelf and the inshore coastal current.

Climate has a major impact on the oceans through its interaction with wind speed, rainfall, evaporation and heat exchange between the air and sea. In the north Atlantic, the main climatic influence is a system called the North Atlantic Oscillation (NAO). A negative NAO results in colder, drier winters in NWW while a positive NAO causes warm and wet winters and cold summers.

Increases in greenhouse gases have caused warming of the atmosphere and ocean, rising sea levels and changing wind patterns. As greenhouse-gas emissions continue to rise, so will the global temperature, leading to further melting of ice and rises in sea level. Key impacts attributed to climate change, observed in the NWW area, are northward distributional shifts of zooplankton, fishes, seabirds, and benthic invertebrates, as well as depth shifts of marine fish species. The ocean is predicted to become more acidic over the next few centuries as a consequence of increased levels of CO_2 in the sea.

The sea bed habitats of the NWW are varied. There are extensive areas of gravel in the Irish Sea and English Channel. Areas of sand occur extensively on the Porcupine and Rockall Banks, the Celtic Sea and in the Irish Sea. Muddy sediments occur in the Irish Sea, the Atlantic Basin, Rockall trough and the Irish Sea. Within NWW there are OSPAR listed and protected habitats along the continental shelf and in inshore waters. Some of the sites are closed to bottom impacting fishing gear in NEAFC and EU waters. There is an extensive network of Special Areas of Conservation (SACs) associated with the EU Habitats Directive (92/43/EEC).

Excess nutrients, or eutrophication, can lead to overgrowth of marine algae. The major sources of nitrogen and phosphorus input in the NWW environment are diffuse losses (agriculture and atmospheric deposition) and sewage treatment works.

In temperate waters, phytoplankton blooms occur in spring, generally followed by smaller peaks in autumn. The zooplankton communities in the NWW are dominated by copepods, and they are an important prey item for many species at higher trophic levels. The ratio between the warm-water copepod species (*Calanus helgolandicus*) and the cold-water species (*Calanus finmarchicus*) has changed in NWW as warming seas resulted in an northward shift of C. *helgolandicus* and a retreat of C. *finmarchicus*.

The coastal and offshore waters of the NWW area provide local breeding and non-breeding seabirds, along with pelagic and passage migrants, with a rich source of nutrition, particularly near coastal upwelling and frontal systems. Amongst locally breeding species, the NWW supports high proportions of the NW European population of the Roseate Tern, the European Storm-petrel, the Manx Shearwater and the Northern Gannet populations. Citizen science provides important contributions to our understanding of NWW seabird distribution and abundance. Special Protection Areas (SPAs) are designated for the protection of wild birds under the European Birds Directive. There are a large number of SPAs distributed along the coasts of NWW.

The leatherback turtle is regularly seen in the NWW area. They breed in tropical areas and are the only species of marine turtle to have developed adaptations to life in cold water. Leatherback populations in the Atlantic are considered to be stable. The data on leatherback turtle sightings depends on the support of the public, who report of any sightings to national sighting data bases.

Cetaceans and seals are the main marine mammals found in NWW. The NWW is an area of particularly high species richness for cetaceans. To date 24 cetacean species have been recorded in Irish and UK waters. This species richness can be attributed to the availability of prey and high productivity along the Atlantic margin of the NWW, which is caused by a warm oceanic current called the North Atlantic Drift. Many cetaceans breed in NWW while others use the area as a migration route. Key data sets on cetacean sightings are collected by the public, who volunteer as marine mammal surveyors and join platforms of opportunity, such as research vessels and ferries. The grey and harbour, or common, seal are the two species of pinniped most common in NWW area.

Due to their reproductive biology, elasmobranchs are particularly vulnerable to over-exploitation. Important nursery areas for sharks, skates and rays exist in NWW. The recordings of eggcases or "mermaids purses" by the public contribute to the understanding of where these areas are located. There has been a substantial decrease in landings of elasmobranchs over the last decade due to declining stocks and increased regulations.

NWW contain important spawning areas for mackerel, horse mackerel and blue whiting along the shelf edge. These species migrate into and out of the NWW area each year. There are also important white fish spawning areas in NWW in the shelf seas and along the shelf edge.

Research surveys use a small mesh to capture juvenile fish. These provide information so that the distribution of juvenile fish can be mapped. There are important fish nursery areas in the NWW area. The shelf and inshore waters are important habitats for juvenile haddock, whiting, cod, monkfish, megrim, hake, mackerel and horse mackerel.

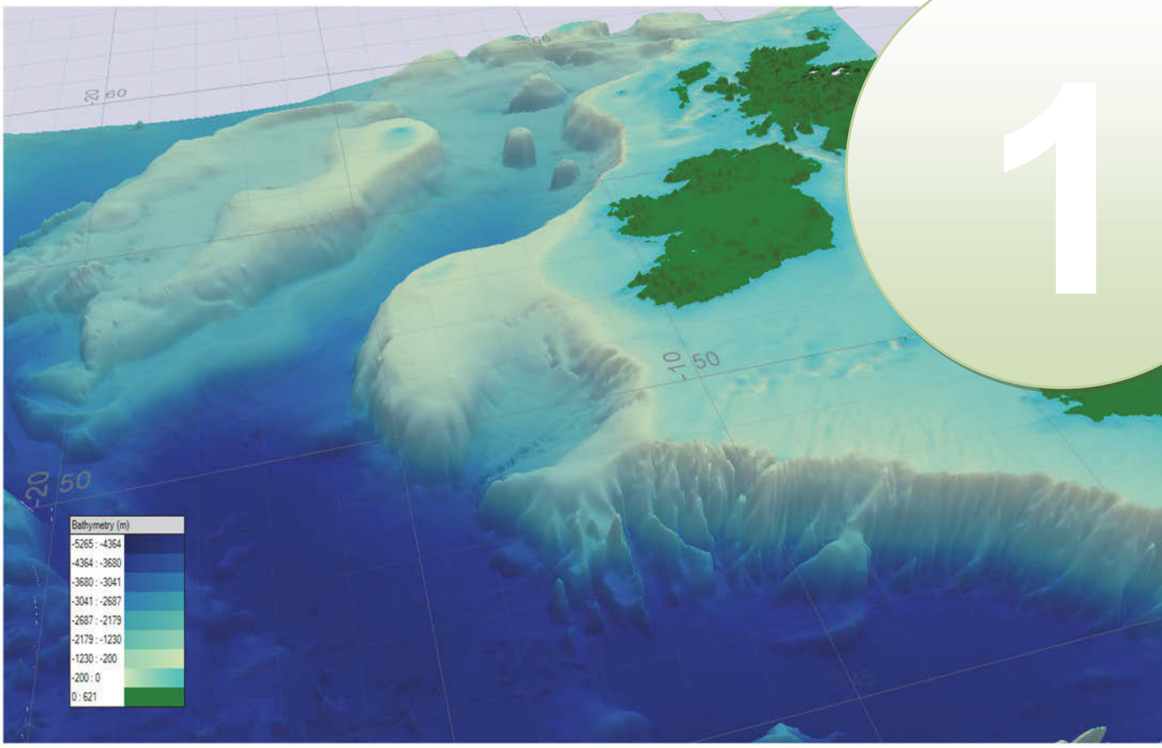
The NWW area contains some of the most productive fishing grounds in Europe. Total landings of wild capture fisheries from the NWW area (i.e. ICES Sub Areas VI and VII) for 2013 were around 1.3 million tonnes. In Sub Area VI (North of Ireland and West of Scotland), the main pelagic species caught are mackerel and blue whiting. The main demersal species taken are hake, saithe, ling, monkfish and haddock. Important shellfish species taken in VI include *Nephrops*, crab and scallops. In Sub Area VII (South and West of Ireland including the Irish Sea), the main pelagic species taken are horse mackerel, mackerel and herring. The main demersal species taken are monkfish, hake, whiting, haddock and megrim. Important shellfish species taken in VII include scallops, whelk, crabs and *Nephrops*. Spatial fisheries management measures in the NWW area include closed areas to protect cod during spawning; extensive deep water closures in the NWW to protect coral grounds, seasonal closures to *Nephrops* fishing on the Porcupine Bank, restricted fishing for cod, whiting and haddock off the west of Scotland and the Biologically Sensitive Area (BSA) off the west and south coasts of Ireland.

The extent and volume of marine aquaculture (mariculture) is increasing in NWW and three species dominate: Atlantic salmon, blue mussel and Pacific cupped oyster. Shellfish production is most significant along the north coast of France while finfish production is most significant on the west coast of Scotland. The production of farmed salmon has seen the largest increase in NWW mariculture over the past two decades.

NWW are subject to a broad range of human activities. There is a network of fishing, commercial and leisure ports and harbours along its coastline, and wide and varied impacts stemming from large coastal cities and towns (e.g. power plants, waste water refining stations, coastal infrastructure, etc.). There are busy shipping lanes leading from the Channel west and southwards. Submarine cables and pipe lines are also concentrated in the Channel and the Celtic Sea. Oil and gas prospecting and extraction occurs in the Celtic Sea and west of Ireland while aggregate extraction is concentrated in the Irish Sea and English Channel. Navigational dredging is common in most shipping ports. Emerging pressures are those associated with increases in renewable energy production while marine tourism is widespread along NWW coasts.

Marine litter can be defined as '*any persistent solid processed material which has been discarded or disposed of in the marine environment*', often including slowly degrading waste items such as plastics, metals and glass. Sources of marine litter in NWW are land based and sea based and range from large items like abandoned fishing gear or derelict fishing vessels to everyday disposable items such as plastic bags, tin cans, right down to microplastics. Microplastics are plastic particles <1mm in length that persist in the environment. There are limited dedicated monitoring programmes for marine litter in NWW and information is supplemented by data from fisheries research surveys and citizen science programmes, which monitor coastal areas.

Ecosystem overviews summarise the main ecosystem components, pressures and impacts in the following five subregions of NWW: Irish Sea, Celtic Sea, West of Scotland and Rockall, Widely Distributed and Migratory Stocks and Deepwater. There has been a strong reduction of fishing mortality on demersal, pelagic and shellfish stocks in all subregions in the last decade. In the Irish Sea there are still a number of severely depleted stocks e.g. cod, whiting and sole. A significant proportion of the catch of the demersal fleets is discarded. There has been an overall increase in spawning stock biomass in the last decade, in particular in the Celtic Sea. Surface waters of the Rockall trough have been steadily warming for some years and are currently at an all-time high. The general and continuing reduction of copepod abundance and recent changes in zooplankton composition throughout the region are causes of concern given the key role that these organisms play in the food web. Most fishing for widely distributed and migratory stocks is pelagic in nature and there is little or no direct effect on the benthic community.



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AREA AND DEPTH

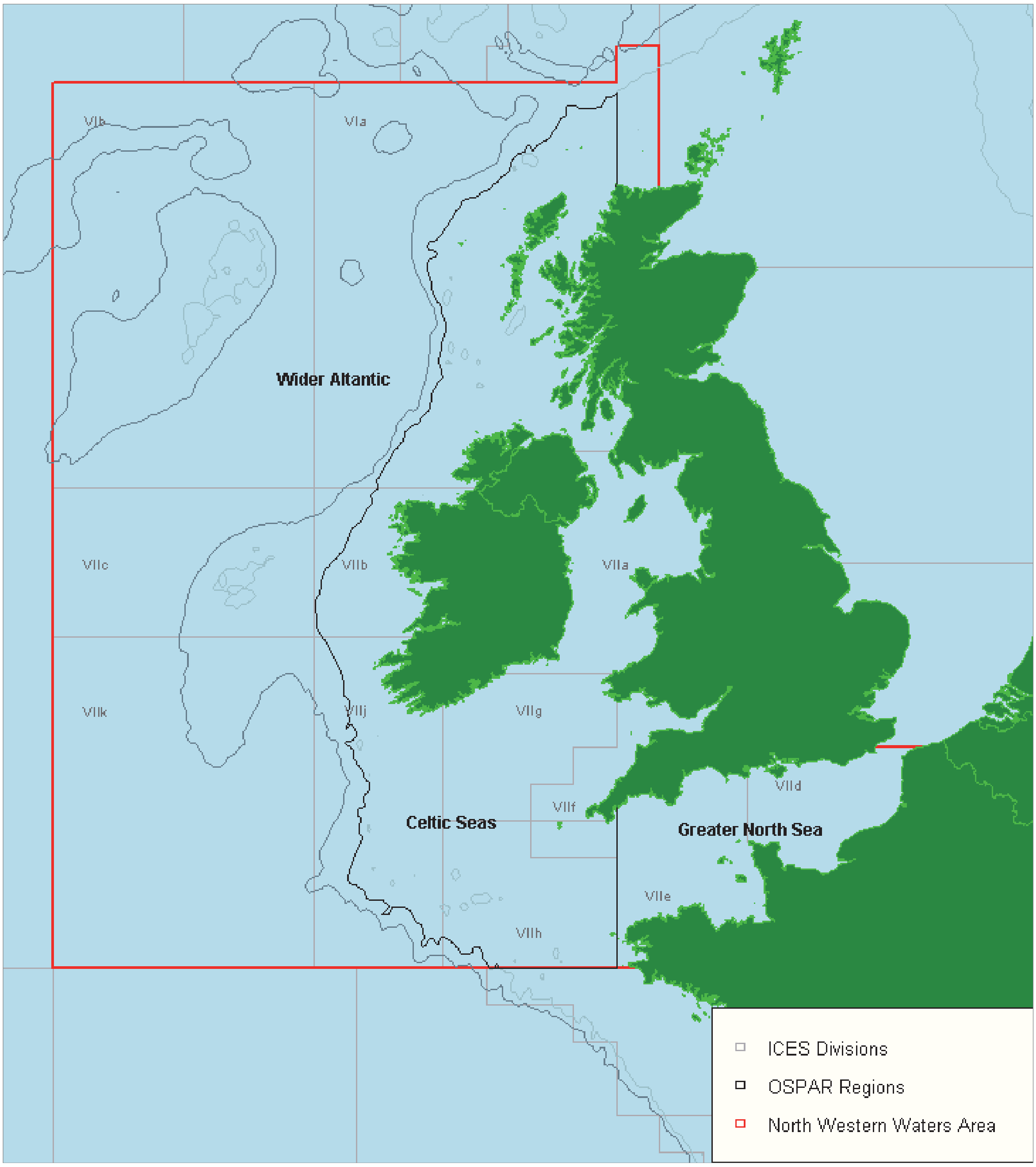
Key Points

The NWW area consists of 12 ICES Divisions and covers an area of approximately 1.15 million km^2. NWW lies within three OSPAR Regions, the Wider Atlantic Region V, the Celtic Seas Region III and the Greater North Sea Region II.

The NWW area comprises the exclusive Economic Zones (EEZ's) for Ireland, part of the UK EEZ and the French EEZ.

The dominant topographic feature of the western part of the NWW Area is the Rockall Trough, a steep-sided elongate depression in the continental shelf, over 1,000 km long and approximately 250 km wide. It is bound to the west by the Rockall Bank, to the east by the Erris and Slyne Ridges and to the north by the slopes of the Porcupine Bank and the Porcupine Ridge.

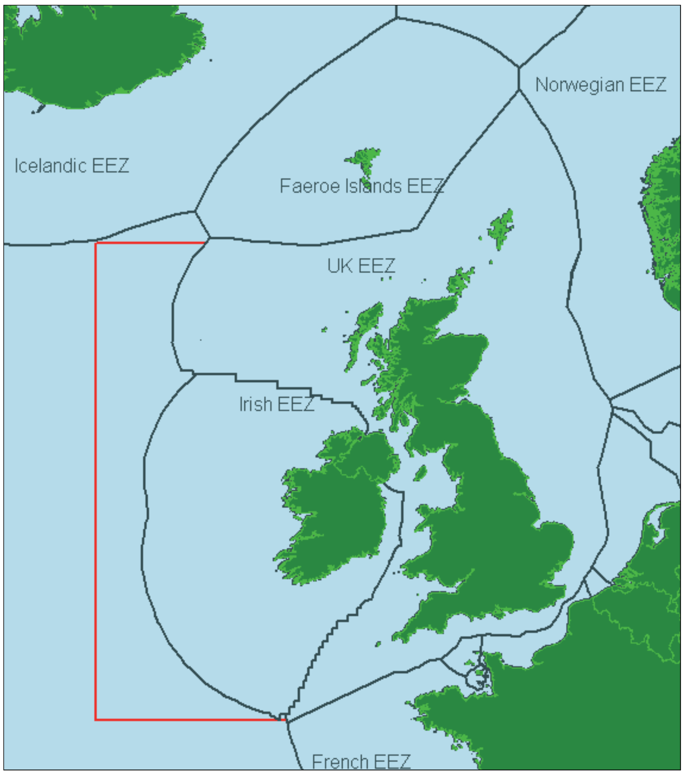
The NWW area consists of the semi enclosed Irish Sea, the English Channel, the Celtic Seas shelf area, the Atlantic slope area and the deep waters off the west of Ireland and Scotland.



▲ The three OSPAR Regions and 12 ICES divisions that are part of the NWW area

The NWW lies within three OSPAR Regions, the Wider Atlantic Region V, the Celtic Seas Region III and the Greater North Sea Region II.

The north Atlantic began to form around 200 million years ago as the European and North American continental plates separated on either side of the mid Atlantic ridge. The Atlantic consists of three depth regimes: the oceanic basins (2,500 to 5,000 m); the continental margins (< 2,500 m) and the continental shelf (< 400 m). The NWW area consists of all three types of regime. The NWW area covers an area of approximately 1.15 million km^2 and consists of 12 ICES Divisions (VIa, VIb, VIIa, VIIb, VIIc, VIId, VIIe, VIIf, VIIg, VIIh, VIIj and VIIk).



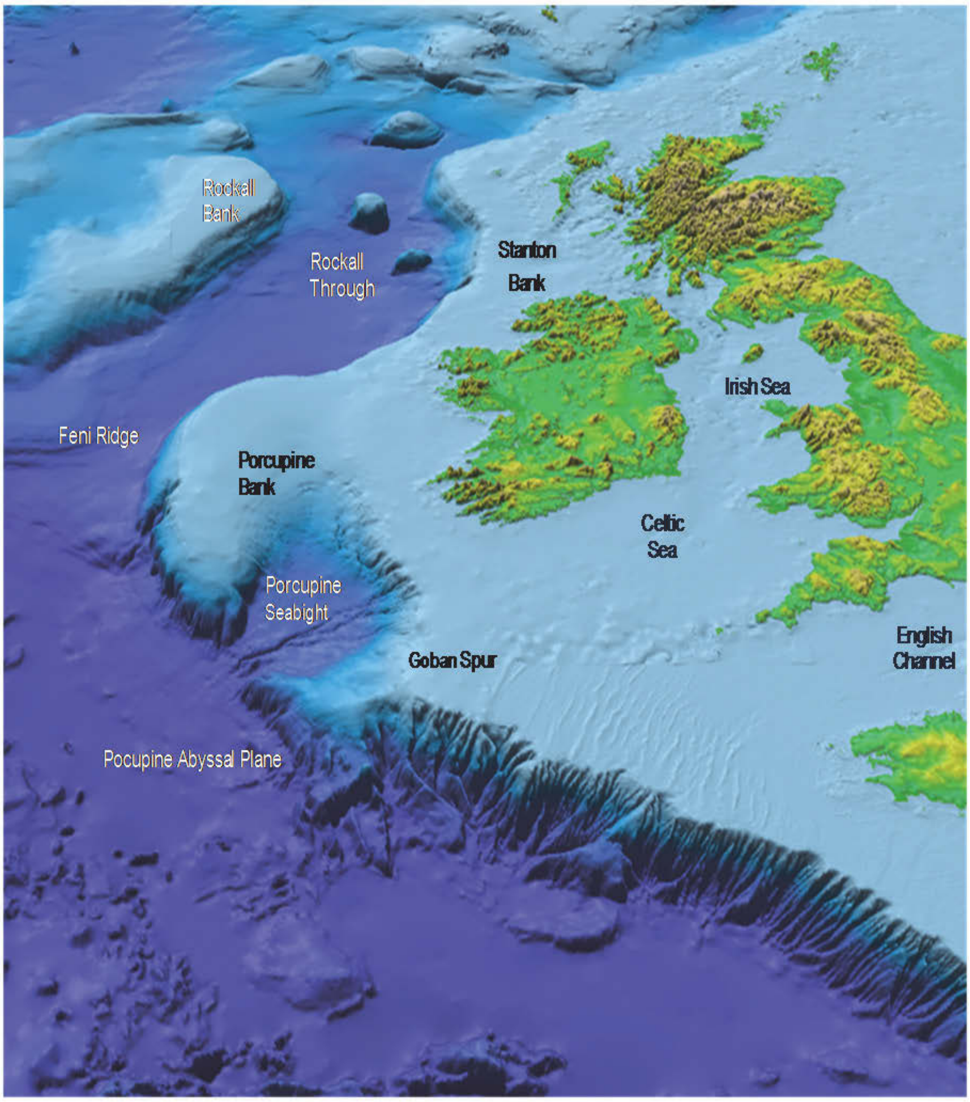
The NWW area comprises the entire Exclusive Economic Zone (EEZ) for Ireland and part of the UK and French EEZ. The UK EEZ covers an area of 763,422 km^2 (including the Channel Islands EEZ), of which approximately 52% lies in the NWW area. The Irish EEZ covers an area of 408,500 km^2 of which 100% lies in the NWW area. The total French EEZ covers an area of 333,700 km^2 of which approximately 20% lies in the NWW area.

The dominant topographic feature of the western part of the NWW Area is the Rockall Trough, a steep-sided elongate depression in the continental shelf, over 1,000 km long and approximately 250 km wide, orientated approximately northeasterly-southwesterly. The trough ranges in depth from 1,000 m to 1,500 m at its northern end west of Scotland where it is bounded by the Wyville-Thomson Ridge and a chain of sea mounts. At its southern end it reaches 3,500 to 4,000 m where it opens onto the Porcupine Abyssal Plain. It is bounded to the west by the Rockall Bank and to the east by the Erris and Slyne Ridges and to the north by the slopes of the Porcupine Bank and the Porcupine Ridge.

Further south, another deep water embayment, the Porcupine Seabight, also opens onto the Porcupine Abyssal Plain. The Seabight ranges in depth from about 350 m at its northern end to over 3,000 m in the south, and is bounded to the east by the Irish Mainland Shelf and the Celtic Shelf, to the north and west by the Porcupine Bank and Porcupine Ridge, and to the south by the Goban Spur. The Porcupine Bank and Ridge, and the Rockall and Hatton Banks, remain as shallower plateau areas separated from the continental shelf by the deep waters of the Rockall Trough and Porcupine Seabight. Inshore of these topographical features is the continental slope.

In the Irish Sea, the seafloor shelves gently westwards from the British coast to water depths of approximately 60 m. This Eastern Shelf is mostly flat and featureless although bathymetric highs and lows occur locally. Shoals with islets and sandbanks occur inshore in the broad bays and estuaries and offshore sandbanks occur parallel to the coast off North Wales and Pembrokeshire and as banner banks northeast off the Isle of Man. In Cardigan Bay there are three shallow water (0 to 10 m) moraine ridges, which extend from the coastline to approximately 15 km offshore. These features are up to 25 km long and 3 km wide, with water depths up to 50 m greater than the surrounding seabed and occur in Morecambe Bay, west of Anglesey and south of Lleyn and are known respectively as the 'Lune Deep', the 'Holyhead Deep' and the 'MuddyHollow'.

The western or Irish Shelf is shallower than 60 m and extends for around 20 km offshore. South of Rockabill and Lambey Islands the Irish Shelf is distinguished by a series of linear, coast parallel, sand banks for its whole length to Carnsore Point, Co. Wexford. The Lambey Deep and Codling Deep are up to 134 m deep.



▲ The dominant topographic features of NWW

Between the Eastern and Irish Shelves, the Celtic Trough is up to 70 km wide and has water depths greater than 60 m. The trough runs from the Celtic Sea to the Malin Sea through St. George's Channel, the western Irish Sea and the North Channel.

Water depths in the southern part of St. George's Channel are approximately 100 m. The seabed is mainly smooth except for locally developed sandwave fields and rare enclosed deeps of approximately 125 m. The bathymetry of the northern part of the channel is more complex with general depths ranging from 60 to 120 m.

There are many sandwaves, some up to 40 m in height and numerous localised enclosed deeps between 130 and 180 m. The area west of the Isle of Man has a smooth, rolling, seabed down to 120 m deep, with rare rocky prominences and enclosed deeps to the north. In the North Channel, the seabed is rough with many rocky outcrops. General depths in the trough are from 60 to 160 m, but there are also both upstanding areas and smaller prominences, some forming rocky islets and the notable complex of enclosed deeps of Beaufort's Dyke, which has a maximum water depth of 315 m. The volume of the Irish Sea is approximately 2,400 km^3, of which 80% lies to the west of the Isle of Man.

WATER MOVEMENTS

Key Points

The main ocean current impacting the NWW area is the Gulf Stream System that draws warm water up from the Gulf of Mexico to the north east Atlantic via the North Atlantic current. This warm seawater releases its heat when it reaches colder areas of the north Atlantic. As the saltwater cools, it becomes denser and heavier and so sinks where it joins the deeper southbound cold water currents that come from the Arctic.

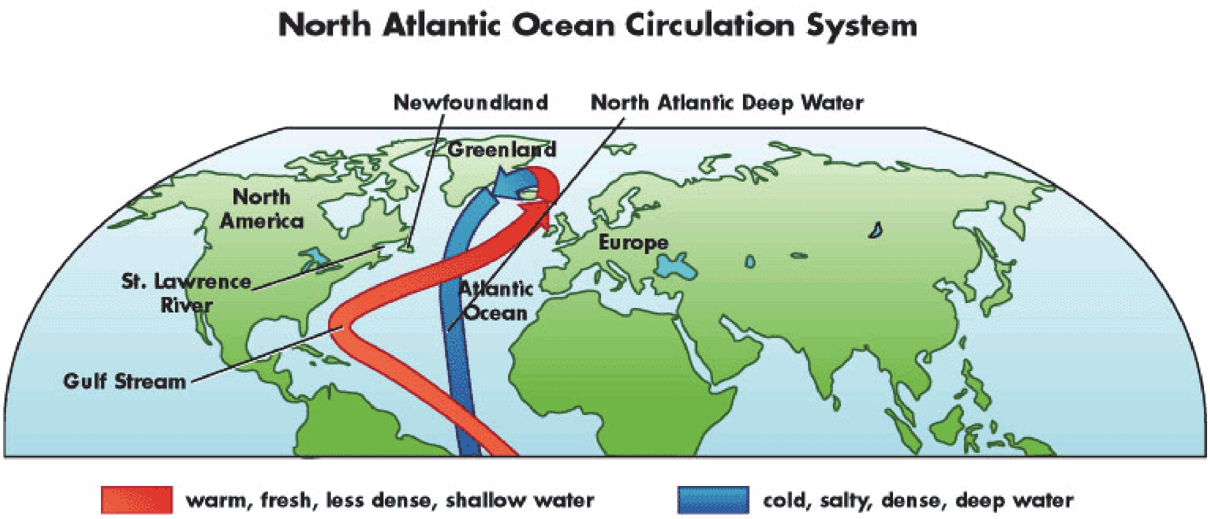
In the north Atlantic, the system of warm water travelling north, losing its heat, sinking and merging with southbound cold currents is part of the Global Conveyor Belt (GCB).

Water circulation in the shallow seas of the NWW is controlled by tides, density differences and winds, and include the shelfedge current along the European shelf and the inshore coastal current. Gyres and "Taylor columns" provide important retention areas in the Irish sea and above offshore banks.

The water masses of the North Atlantic Ocean are continuously moving under the influence of tides, winds and storms. In the north Atlantic vast ocean currents bring warm water up from the tropics to the European shelf and transport cold water southwards. The main ocean current affecting the NWW area is the Gulf Stream System that draws warm water up from the Gulf of Mexico to the north east Atlantic via the North Atlantic current. This warm seawater releases its heat when it reaches colder areas of the north Atlantic. As the saltwater cools, it becomes denser and heavier and so sinks where it joins the deeper southbound cold water currents that come from the Arctic.

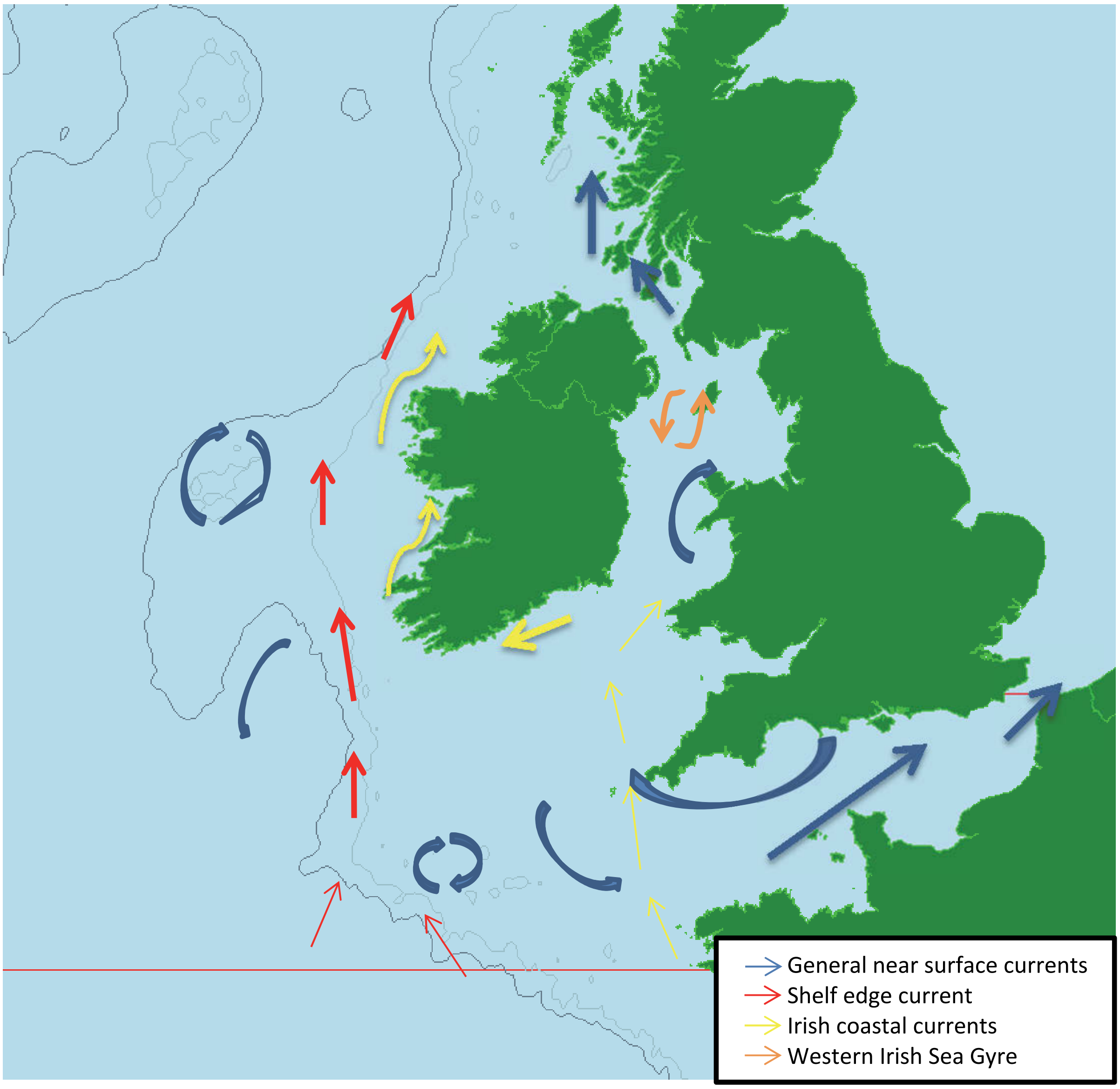
The Global Conveyor Belt

Global ocean currents work in three dimensions. In the north Atlantic, the system of warm water travelling north, losing its heat, sinking and merging with southbound cold currents is part of the Global Conveyor Belt (GCB). The GCB keeps the NWW and adjacent Seas moving and mixes warm water with cold water, thus mixing nutrient poor and nutrient rich water. This process supports the rich ecosystems of the north east Atlantic.



▲ General schematic of the surface currents of the North East Atlantic (Source: www.giss.nasa.gov).

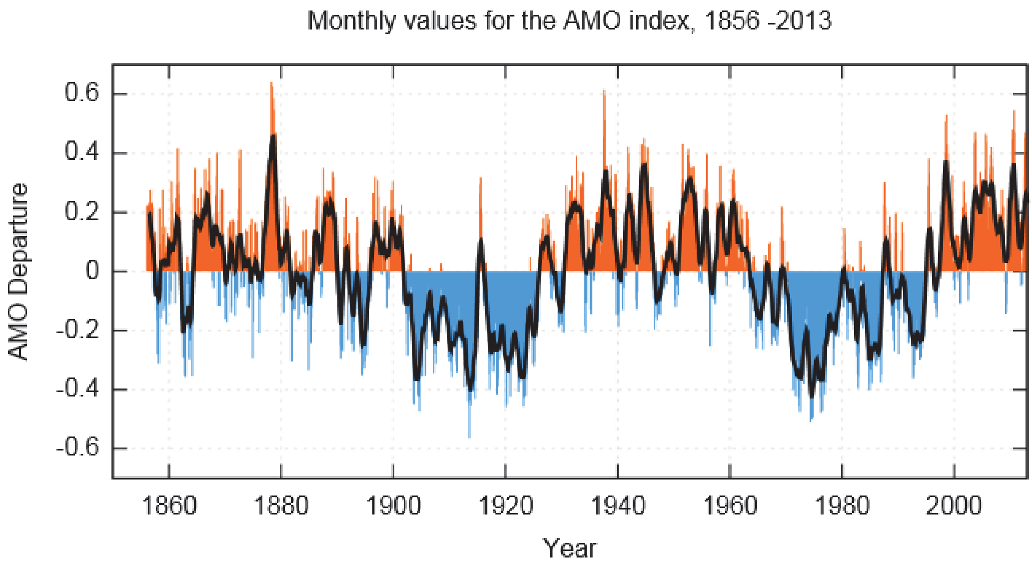
Water circulation of the shallow shelf of the NWW area is controlled by the combined effects of tides, density differences and winds. The Shelf Edge Current is formed at the boundary between stratified deeper water off the shelf and shallow, tidally mixed waters on the shelf. The Shelf Edge Current is an important transport mechanism for the eggs and larvae of important commercial fish species. The Coastal Current is a density driven circulation that forms close to the coast where fresh water runoffs mix with sea water. Bathymetric features, i.e. elevations and depressions can results in circular water currents such as the western Irish Sea Gyres and the "Taylor column" above the Porcupine Bank. These features create important retention areas for nutrients and plankton, including fish eggs and larvae.



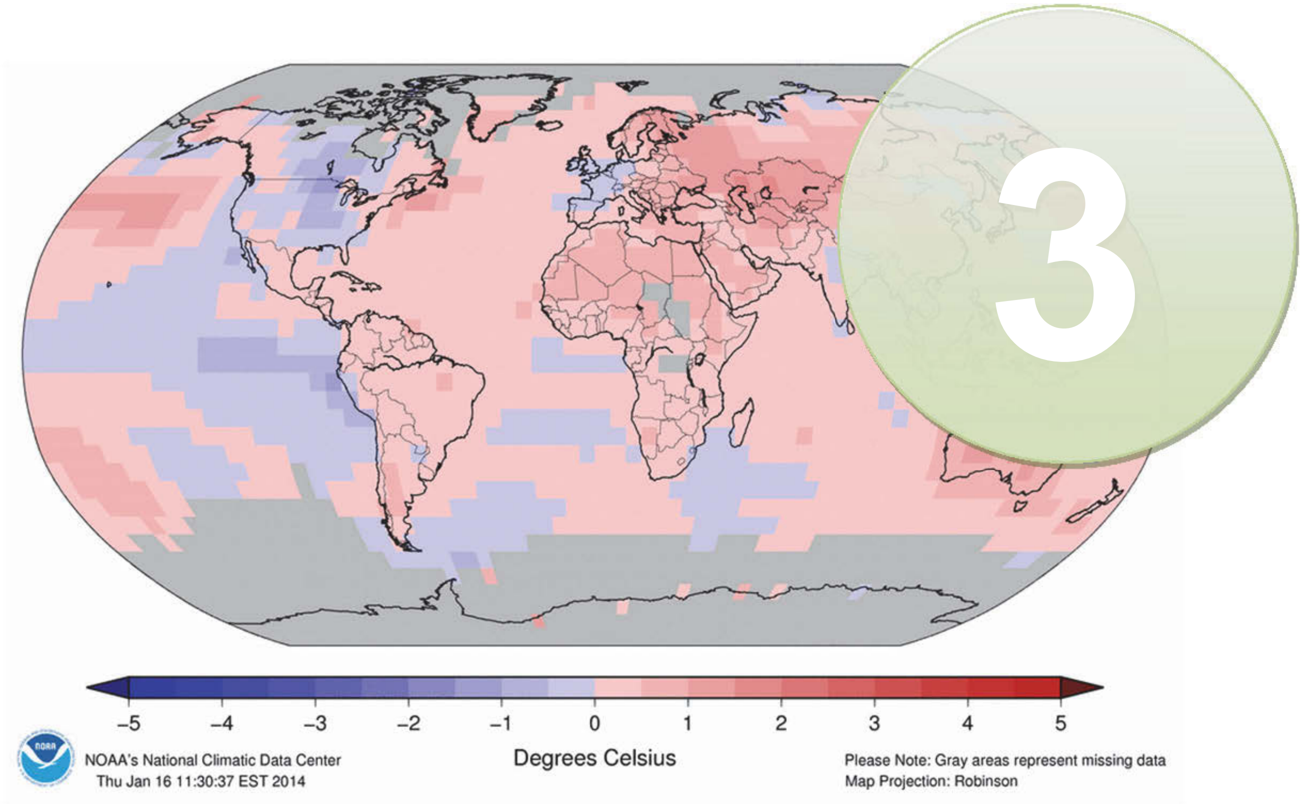
▲ General schematic of the surface Currents of the North East Atlantic (Source: atlas.marine.ie, 2014).

The Atlantic Multi-decadal Oscillation (AMO)

In the north Atlantic, there are recognised long term oscillations in ocean temperature that are linked to atmospheric conditions. During the 20th century the period 1900 to 1930 and 1960 to 1990 were characterised by cool periods in sea surface temperature while the periods 1930 to 1960 was characterised by warmer sea surface temperatures. This decadal scale oscillation is known as the **Atlantic Multi-decadal Oscillation (AMO).** The AMO is linked to changes in weather patterns on both sides of the Atlantic.



▲ Atlantic Multidecadal Oscillation (AMO) Timeseries with a 12 month moving average (black), 1856–2013 Source: http://www.cdc.noaa.gov



▲ Ocean Temperature Anomalies Jan – Dec 2013 with respect to 1981 to 2010; data source: GHCN-M vers. 3.3.3 & ERSST vers. 3b; image from ncdc.noaa.gov.

CLIMATE AND SEA TEMPERATURE

Key Points

Climate has a major impact on the oceans through its interaction with wind speed, rainfall, evaporation and heat exchange between the air and sea. In the north Atlantic, the main climatic influence is a system called the North Atlantic Oscillation (NAO). A negative NAO results in colder, drier winters in NWW while a positive NAO causes warm, wet winters and cold summers.

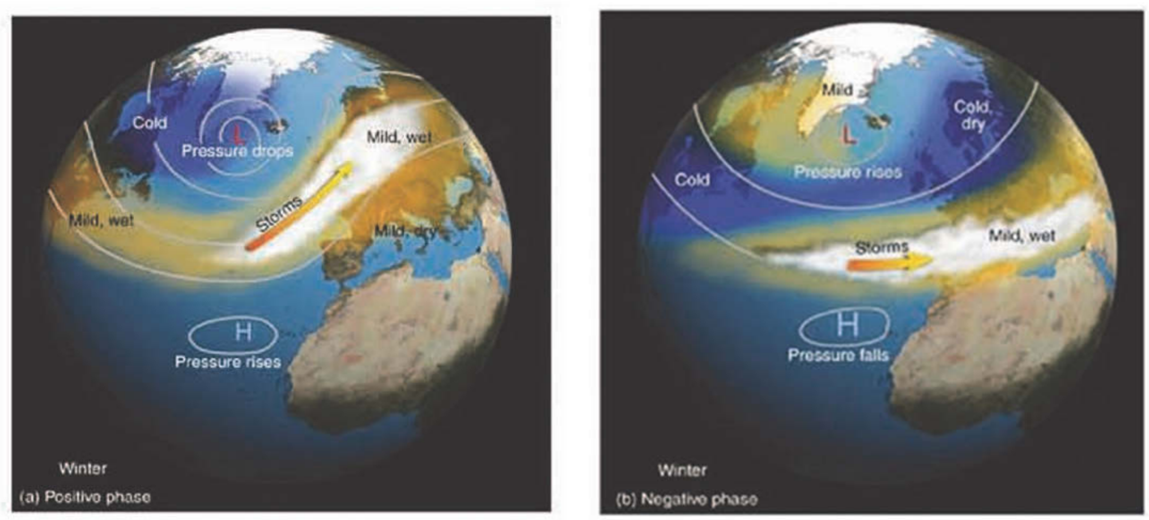
Increases in greenhouse gases have caused warming of the atmosphere and ocean, rising sea levels and changing wind patterns. As greenhouse-gas emissions continue to rise, so will the global temperature, leading to further melting of ice and rises in sea level.

Key impacts attributed to climate change, observed in the NWW area, are northward distributional shifts of zooplankton, fishes, seabirds, and benthic invertebrates, as well as depth shifts of marine fish species.

The ocean is predicted to become more acidic over the next few centuries as a consequence of increased levels of CO_2 in the sea. This has major implications for marine animals and plants that make their shells and plates out of calcium carbonate (CaCO3), with calcified molluscs, echinoderms, and reef-building corals being most sensitive.

Climate has a major impact on the oceans through its interaction with wind speed, rainfall, evaporation and heat exchange between the air and sea. The growing realisation that human action is affecting the earth's climate has developed at the same time as the recognition of the importance of naturally occurring variations in the climate. Climate change represents the human induced warming trend on the climate, while climate variability refers to the "natural" cycles of change in climate over a defined time scale (e.g. decadal scale).

In the north Atlantic, the main climatic influence is a system called the North Atlantic Oscillation (NAO). The NAO represents the difference between two persistent sets of contrasting air pressure – high pressure over the Azores and low pressure over Iceland. When the pressure over the Azores is higher and the pressure over Iceland lower than usual, the NAO is in a positive phase. This results in warm, wet winters and cold summers in the NWW area. A negative NAO phase comes from weaker air pressure differences between the Azores and Iceland. This results in colder, drier winters in NWW and wetter winters in the Mediterranean.



▲ Pressure systems over Iceland (Icelandic low) and the Azores (Azorean high) defining the North Atlantic Oscillation: The pattern associated with a positive (NAO+; right) and a negative (NAO-; left) phase of the index. – (Source Thomson Higher Education 2007)

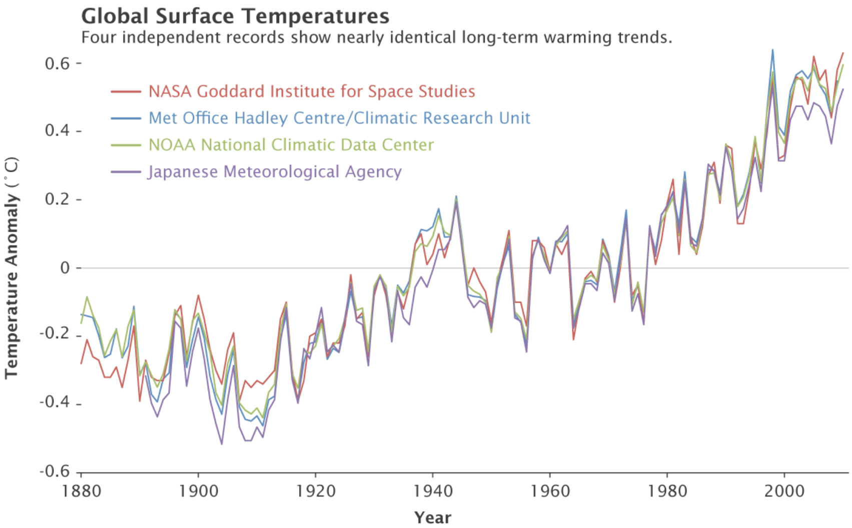
"Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia.

The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased."

IPCC, 2013: Summary for Policymakers.

In their Climate Change update, ICES have stated that there is "great confidence within the scientific community that climate change is a reality. Global atmospheric concentrations of the 'greenhouse' gases – carbon dioxide (CO_2), methane, and nitrous oxide – have increased as a result of fossil fuel use and changing systems of agriculture".

The increase in these gases has caused warming of the atmosphere and ocean, rising sea levels, and changing wind patterns. As greenhouse-gas emissions continue to rise so will the global temperature, leading to further melting of ice and rises in sea level.



"It is virtually certain that the upper ocean (0-700 m) warmed from 1971 to 2010 and it likely warmed between the 1870s and 1971"

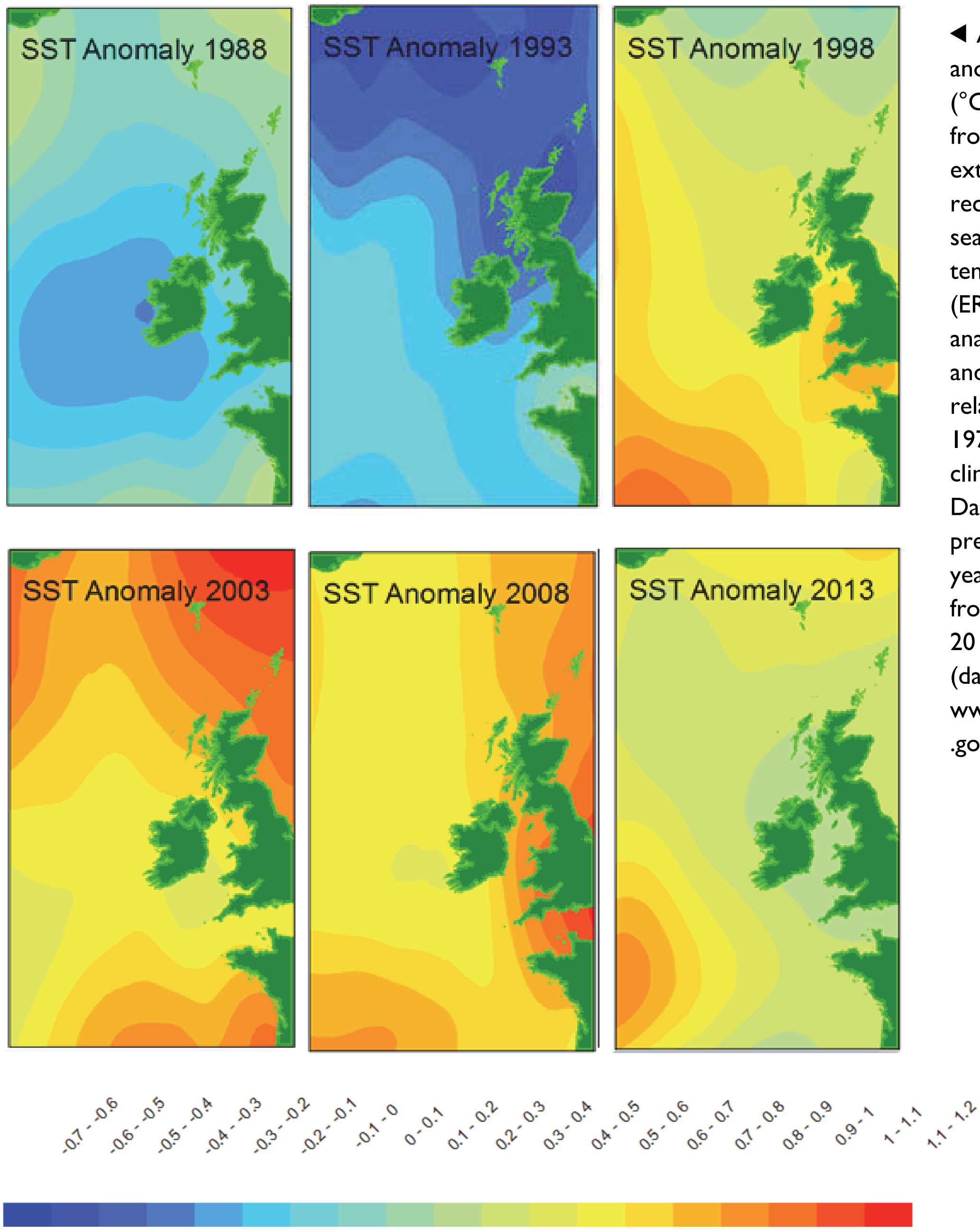
IPCC, 2013: Summary for Policymakers.

▲ Source NASA Earth Observatory, Richard Simmons

In North Western Waters, strong warming has been observed in the last three decades with sea surface temperatures around the UK and Ireland warming at rates up to six times greater than the global average. It remains difficult to fully distinguish the natural variations in temperature from those caused by humans.

Despite long-term warming trends, temperature changes are not always linear or smooth. Sea surface temperatures (SST) can change rapidly over a short period in one area with less change in another location, making it difficult to summarise overall trends. In NWW, the SSTs since 2008 observed in most areas have not risen compared to those in 2003-2007. This is attributed to a combination of global climate change and natural variability in the ocean atmosphere system.

Temperature increases are predicted to continue over the 21st century in the shelf seas of the NWW, perhaps at a lesser average rate to that observed in the last 30 years. Natural variability, driven by atmospheric and oceanic processes make it difficult to predict the direction of temperature change over the next decade (from MCCIP Science Review 2013, www.mccip.org.uk).



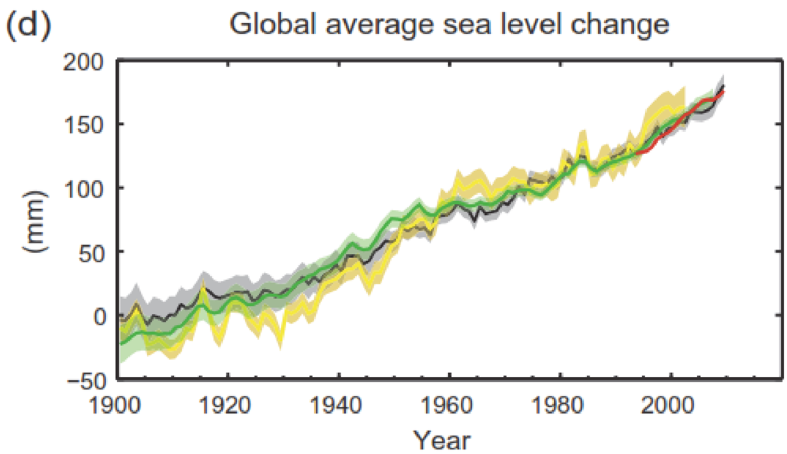
◀ Annual mean anomalies SST (°C) derived from the extended reconstructed sea surface temperature (ERSST) analysis dataset and calculated relative to the 1971 to 2000 climatology. Data are presented at 5 year intervals from 1988 to 2013 (data source: www.ncdc.noaa.gov).

Thirty year climatologies of sea surface temperatures show strong temperature differences in the northeast of the NWW area between 1993 and 2003 with relative temperature differences of more than 1.5°C. Temperature values of up to 0.8°C higher than the long term mean have been observed in the south and southwest of NWW in the last 25 years.

Climate Change Impacts on the NWW ecosystem
Biological Impacts

Phytoplankton	– Shift in Species Abundance and Distribution
Harmful Algal Blooms	– Increasing Incidence
Fish	– Shift in latitudinal and depth distributions
Mammals	– Loss of Habitat and Change in Food Supply
Seabirds	– Change in Food Supply
Non Indigenous Species	– Increased Invasions and Establishments
Intertidal Communities	– Change of Species Range
Benthic Ecology	– Vulnerable to abrupt and extreme events

Based on OSPAR, 2010 and ICCP, 2014)



◄ Global mean sea level relative to the 1900–1905 mean of the longest running dataset, and with all datasets aligned to have the same value in 1993, the first year of satellite altimetry data (from IPCC, 2013: Summary for Policymakers).

Climate Change Impacts on the NWW ecosystem
Physical and Chemical Impacts

Increased Sea Temperature	Reduced Uptake of CO_2 by the Ocean
Increasing Freshwater Inputs	Acidification of the Ocean
Changed Salinity	Nutrient Enhancement
Shelf Sea Stratification	Coastal Erosion
Increased Storms	Slower Atlantic Ocean Circulation
Increased Sea Levels	Nutrient Enrichment

(Based on OSPAR, 2010)

The ocean is also predicted to become more acidic over the next few centuries as a consequence of increased levels of CO_2 in the sea. This will have major implications for marine animals and plants that make their shells and plates out of calcium carbonate ($CaCO_3$). The process of "calcification", which for some marine organisms is important to their biology and survival, will be reduced as the water becomes acidic (less alkaline). For medium - to high emission scenarios, the IPCC has predicted that ocean acidification poses substantial risks to marine ecosystems with highly calcified molluscs, echinoderms, and reef-building corals being most sensitive (IPCC summary report to policy makers, 2014).

4

SEA FLOOR HABITAT

Key Points

Gravelly sediments occur extensively in the Irish Sea, English Channel and Malin Shelf.

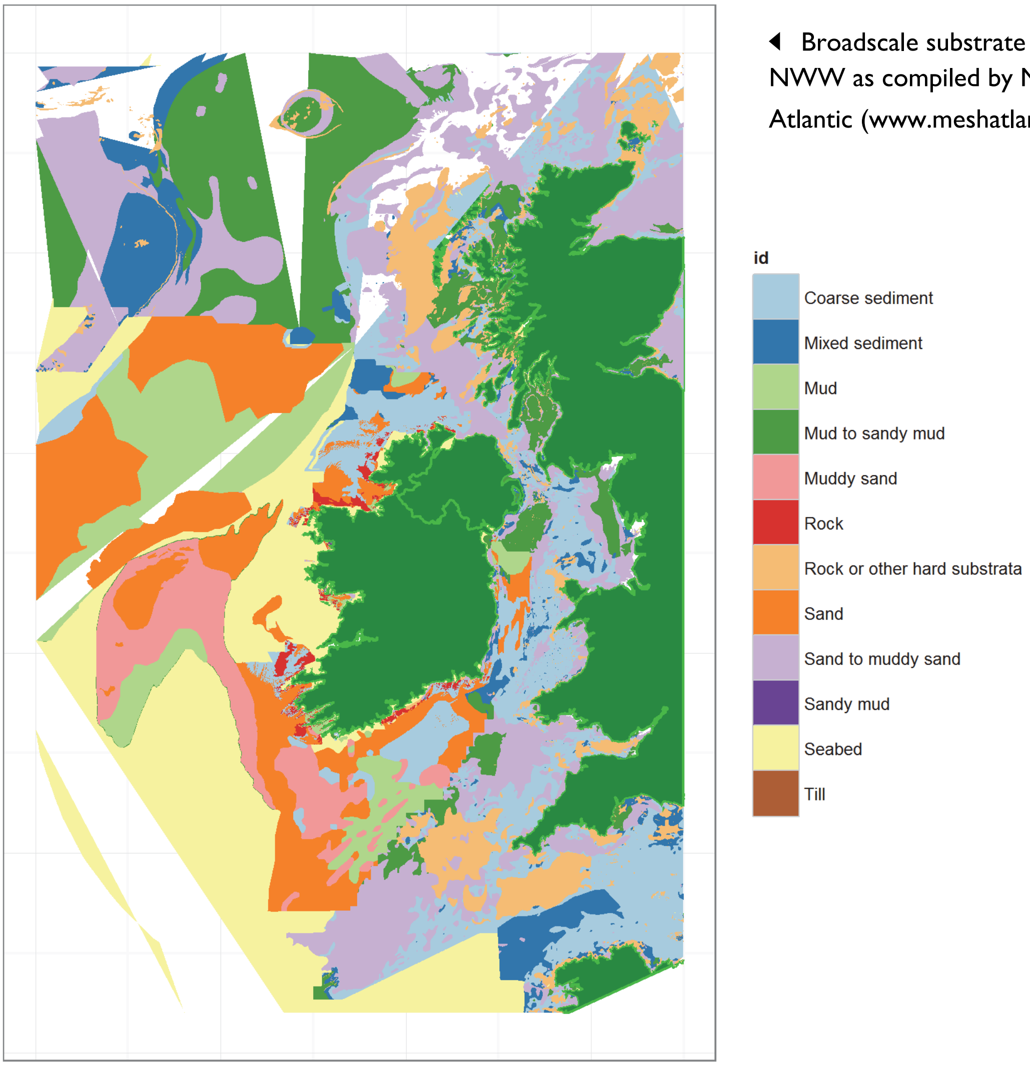
Areas of sand in NWW occur extensively on the Porcupine and Rockall Banks, the Celtic Sea and areas of the Irish Sea, where sandwaves and mega-ripples occur north of the Isle of Man, in Liverpool Bay and Cardigan Bay and also in St. George's Channel.

Muddy sediments occur throughout NWW, particularly in the north of the Irish Sea, in two large areas separated by the central belt of gravelly sediments, in the Atlantic Basins, Rockall Trough and southern Celtic Sea.

Within NWW there are OSPAR listed and protected habitats along the continental shelf and in inshore waters. Some of the sites are closed to bottom impacting fishing gear in NEAFC and EU waters.

There is an extensive network of Special Areas of Conservation (SACs) associated with the EU Habitats Directive (92/43/EEC).

The benthic habitats within the NWW RAC are presented here in relation to their substrate. This map was produced by the MESH Atlantic project (Mapping European Seabed Habitats, http://www.meshatlantic.eu) where the focus is on mapping according to the EUNIS habitat classification. In addition to the EUNIS classification, each EUNIS habitat type can be linked to different biotopes around the British Isles. A biotope is defined as an area of uniform environmental conditions with a specific assemblage of organisms.



◄ Broadscale substrate map of NWW as compiled by MESH Atlantic (www.meshatlantic.eu)

Further Information on Habitat Types

Detailed descriptions of the biotopes and how they relate to EUNIS classification can be found on the JNCC website (www.jncc.gov.uk). The descriptions include substrate type, physical characteristics (including wave exposure, tidal stress, salinity etc.), depth distributions and biological characteristics (including species compositions).

Gravel

Gravelly sediments occur extensively in the Irish Sea, English Channel and Malin Shelf. Within the Irish Sea they occupy a broad belt in the centre of the northern Irish Sea extending from Scotland, past the Isle of Man, to Anglesey and are predominant in the Northern Channel, Cardigan Bay and St. George's Channel. There are also large areas of exposed till in St. George's Channel and areas of exposed bedrock occur locally in the North Channel and between Anglesey and the Isle of Man. The gravelly areas, and the areas of exposed till and bedrock, mainly occur in regions dominated by strong tidal currents or wave action as the strong currents prevent the deposition of fine material.

Sand

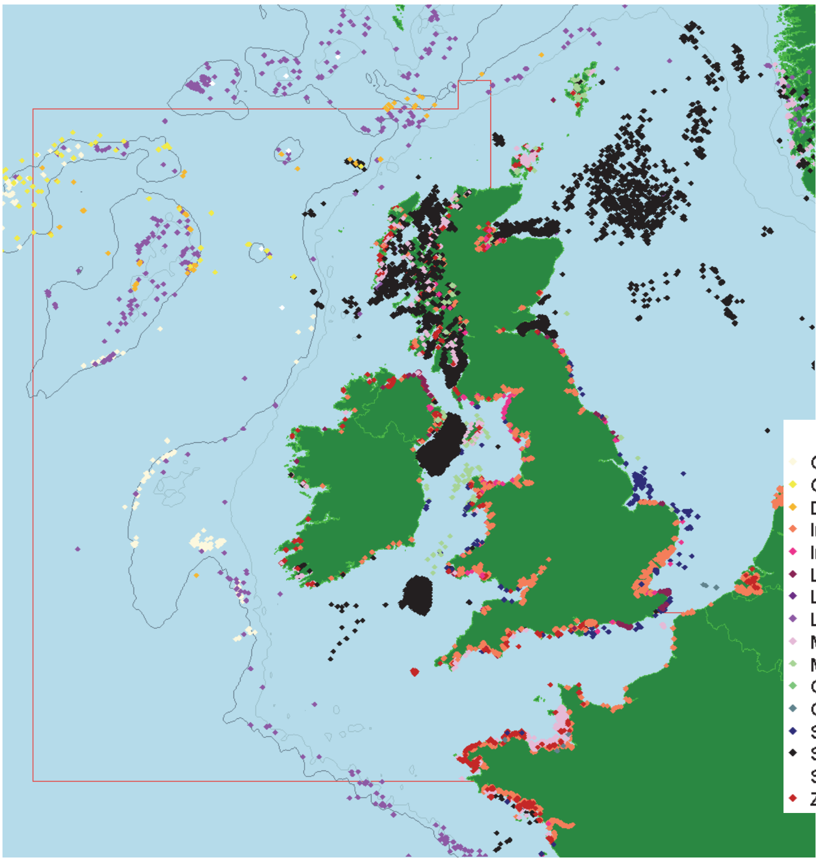
Areas of sand in NWW occur extensively on the Porcupine and Rockall Banks, the Celtic Sea and areas of the Irish Sea, where areas of sandwaves and megaripples occur north of the Isle of Man, in Liverpool Bay and Cardigan Bay and also in St. George's Channel. Tidal sand banks and sand ridges occur in the Solway Firth, north of the Isle of Man, in Liverpool Bay, south of Lleyn Peninsula and off the east coast of Ireland.

Mud

Muddy sediments occur throughout the NWW, particularly in the north of the Irish Sea, in two large areas separated by the central belt of gravelly sediments, in the Atlantic Basins, Rockall Trough and southern Celtic Sea. The main concentration in the Irish Sea is in the area between the Isle of Man and Northern Ireland, where the sediments have very high mud content. Other areas of muddy sediments also occur in St. George's Channel and smaller areas can be found locally in coastal areas off rivers and estuaries and in small bathymetric depressions.

Listed Habitats

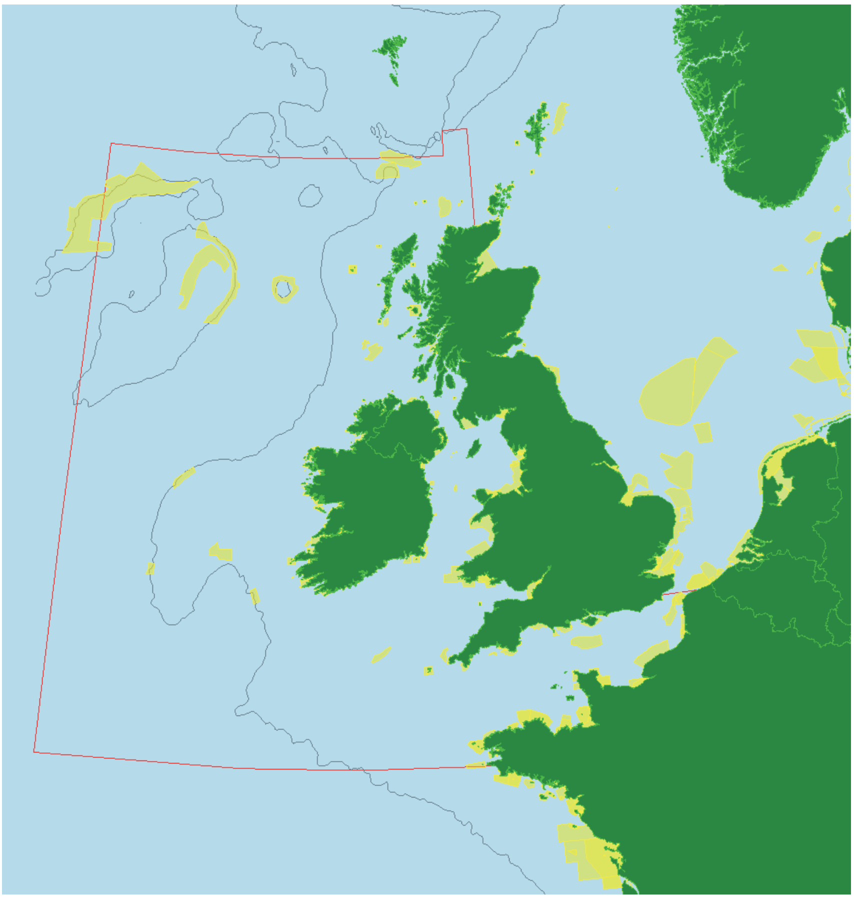
There are habitat types that are considered fragile, vulnerable or threatened, these are designated to warrant special protection. OSPAR has established a list of threatened and/or declining habitats in the North-East Atlantic to guide the setting of priorities for conservation and protection of marine biodiversity under Annex V of the OSPAR Convention.



◀ Distribution of threatened and declining habitats as listed by OSPAR (data from www.ospar.org and mapped by MarineAtlas.ie)

Habitat Protection

Special Areas of Conservations are designated sites under the EU Habitats directive (92/43/EEC) and include inshore habitats such as maerl and zostera beds, while cold water corals are designated offshore SACs.



▶ Map of Special Areas of Conservation (SACs) from the Marine NATURA 2000 network within the NWW.

CONTAMINANTS AND NUTRIENTS

KEY POINTS

Contaminants are chemical substances that are detected in locations where they should not normally be found. The effects of contaminants on marine organisms (animals and plants) vary depending upon their behavior and fate following release to the environment.

Contaminants can be natural or manmade and fall into four main groups:

- Trace metals: metals such as cadmium and mercury, which are generated in metallurgic industries such as the manufacture of batteries, and copper, which is widely used as an antifoulant;
- Organic compounds: including pesticides and herbicides that occur in agricultural runoff;
- Oil: from energy extraction and marine transport;
- Radioactive elements: radioactive caesium is released from nuclear reprocessing operations.

Excess nutrients, or eutrophication, can lead to overgrowth of marine algae. The major sources of nitrogen and phosphorus input in the NWW environment are diffuse losses (agriculture and atmospheric deposition) and sewage treatment works.

Contaminants

Contaminants are chemical substances that are detected in locations where they should not normally be found. Their input to marine areas follows three main routes: directly into the sea, via rivers, or via the atmosphere. The relative importance of these routes depends on the substance in question and the geographic area. In the open ocean, inputs from the atmosphere are the most important while in coastal areas, riverine and direct inputs are more significant.

Contaminants can be natural or manmade and in the marine environment fall into four main groups: 1) Trace metals such as cadmium and mercury, which are generated in metallurgic industries such as the manufacture of batteries and copper used as an antifoulant 2) Organic compounds including pesticides and herbicides that occur in agricultural runoff 3) Oil from energy extraction and marine transport 4) Radioactive elements such as caesium released from nuclear reprocessing operations.

The effects of contaminants on marine organisms (animals and plants) vary depending upon their chemical behaviour and fate following release to the environment. After release, substances can remain in the water (either in solution or attached to small particles), be deposited in sediments, or be taken up by organisms. Some contaminants can also be transported long distances from their sources by ocean currents and through the atmosphere. Transport through the atmosphere is a particularly important mechanism in transferring certain persistent organic compounds from their sources in temperate latitudes (e.g., the USA and Europe) to the Arctic regions. The uptake of substances by organisms (bioavailability) is an important feature in determining their effects.

Examples of Marine Contaminants

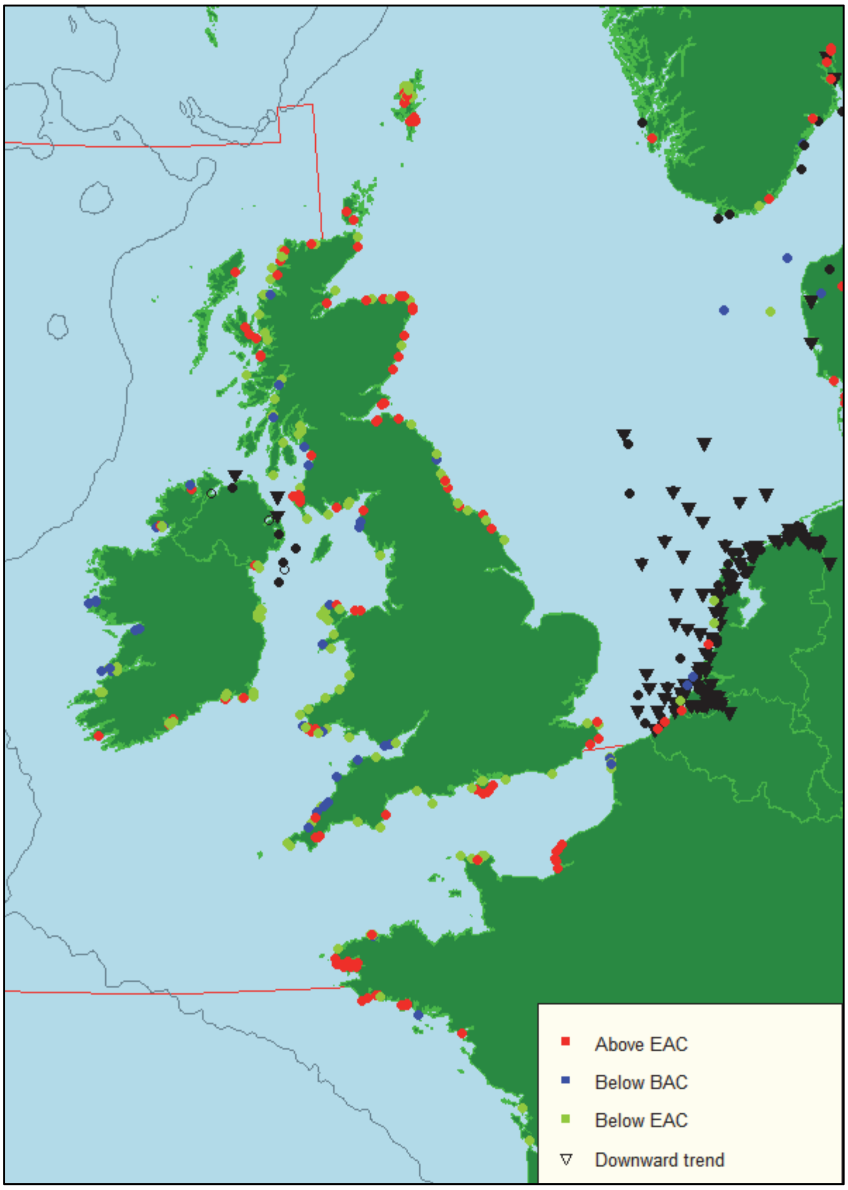
Antifoulants are used to prevent the growth of marine plants and animals on the hulls of ships, as this growth slows the vessels down and increases their fuel consumption.

Drill cuttings are the fragments of rock removed when a well is being drilled, the associated fluid circulating within the drilling system aids removal of the cuttings from the hole and can be used to lubricate the drill itself.

Produced water is water from the underground formation that rises to the surface with the oil. This is cleaned on board the production platform and then either discharged overboard or returned to the formation (re-injected).

Chlor-alkali plants manufacture chlorine gas and caustic soda by the electrolysis of sodium chloride brine. Brine sludge is a by-product and may contain magnesium, calcium, iron, and other metal hydroxides.

Dioxins are by-products of industrial processes and low-temperature incineration (particularly of plastics). They bio-accumulate in animals and can cause sterility and cancer.



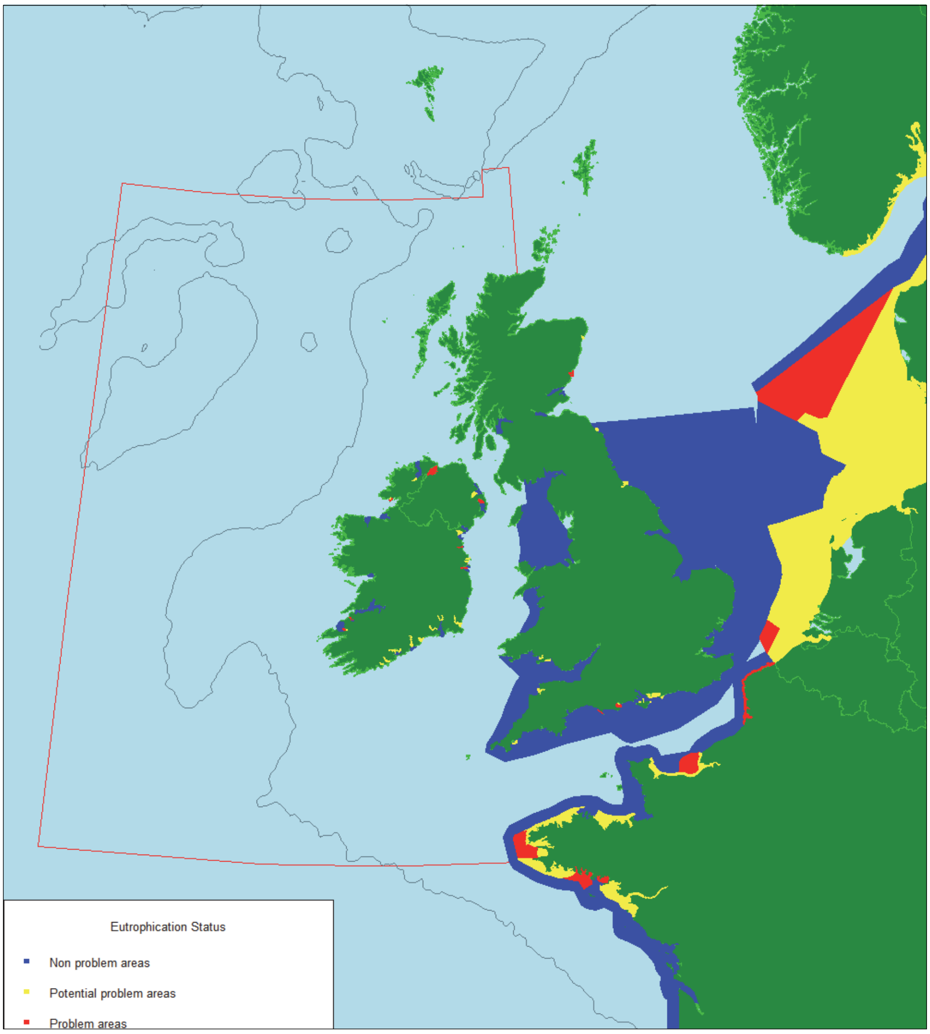
◀ Overview of all biological effect and chemical measurements of TBT in sediment and biota relating to organotin; red symbols- above Environmental Assessment Criteria (EAC), blue below Background Assessment Concentrations (BAC), green below EAC, triangle down- downward trend. Source: OSPAR CEMP assessment 2012.

"A decrease in contaminant inputs to the North-East Atlantic since 1990 is reflected in the decrease in concentrations for four of the seven contaminants (i.e., lead, lindane, PCB and DDT) in mussels and fish in this region" (EEA 2011).

Nutrients

Eutrophication is defined as the anthropogenic enrichment of water by nutrients, (principally nitrates and phosphates) causing an accelerated growth of algae and higher forms of plant life. This produces an undesirable disturbance of water quality itself and the balance of organisms present in the water. High nutrient levels can lead to depletion of oxygen (anoxia) followed by loss of bottom dwelling animals and shifts in the structure of the food web.

The urbanization of coastal areas is associated with nutrient releases and related pressures on the marine environment, e.g. from waste water treatment plants or from economic activities. The most important sources contributing to eutrophication in the NWW maritime area are agriculture, atmospheric deposition, urban waste water, industry and agriculture. The major sources of nitrogen and phosphorous input in the environment are diffuse losses (agriculture and atmospheric deposition) and sewage treatment works. A major contribution to atmospheric deposition, and therefore to the overall input of nitrogen to the environment, is the emission by international ship traffic.



◄ NWW Eutrophication status in 2007 (from OSPAR common procedure, see www.ospar.org)

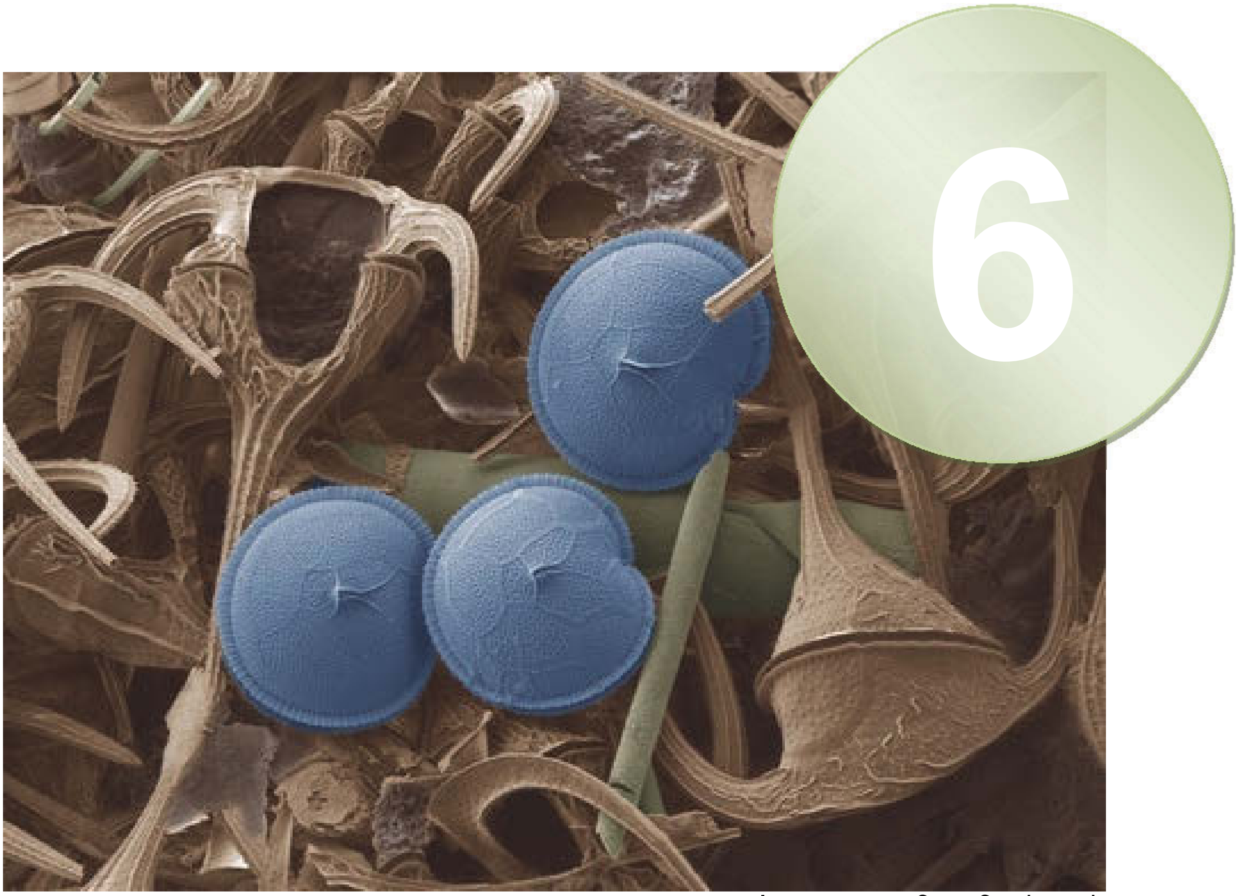
Nitrogen and Eutrophication

The greater North Sea is the most problematic region in the North-East Atlantic in terms of eutrophication. Reasons for this are high population densities and related high nutrient inputs, mostly via rivers. Furthermore the shallow character of the shelf sea and its hydrodynamics enhance eutrophication processes. For the Greater North Sea atmospheric deposition of nitrogen is estimated to represent one third of all nitrogen inputs.

In the NWW, eutrophication is restricted to fjords, estuaries and harbours, where the pressures are associated with higher population densities and agricultural activities. Atmospheric deposition of nitrogen is estimated to provide about one third of all inputs of nitrogen.

The Bay of Biscay and the Iberian Coast are also less affected by eutrophication processes because the hydrodynamic conditions at the open ocean (e.g. fast dilution) inhibit the conversion of discharged nutrients to extended phytoplankton blooms. Eutrophication is therefore limited to a few inshore areas.

Total inputs of nitrogen in the wider Atlantic are very low compared to the other regions. Atmospheric deposition is estimated to be the largest source.



▲ Image source: SuperStock.co.uk

PLANKTON

Key Points

Plankton consists of drifting organisms that inhabit the pelagic zone of the oceans and they provide a crucial source of food for many organisms. The plankton community comprises a plant component (phytoplankton) and an animal component (zooplankton).

The local abundance of plankton varies horizontally, vertically and seasonally. The main cause of this variability is the availability of light and nutrients.

The zooplankton communities in the NWW are dominated by copepods, and they are an important prey item for many species at higher trophic levels. The ratio between the warm-water copepod species (*Calanus helgolandicus*) and the cold-water species (*Calanus finmarchicus*) has changed in NWW as warming seas resulted in an northward shift of *C. helgolandicus* and a retreat of *C. finmarchicus*.

The plankton community comprises a plant component (phytoplankton) and an animal component (zooplankton). The biology and ecology of plankton is closely coupled with environmental factors and as a result they act as an important link between the biological and physical components of the marine ecosystem. Changes in plankton populations will have impacts on organisms at higher trophic levels, with important environmental and economic consequences.

The majority of the plankton is found within the top 20 m of the water column, where light can penetrate thus allowing photosynthesis to take place. The phytoplankton community is dominated by dinoflagellates and diatoms.

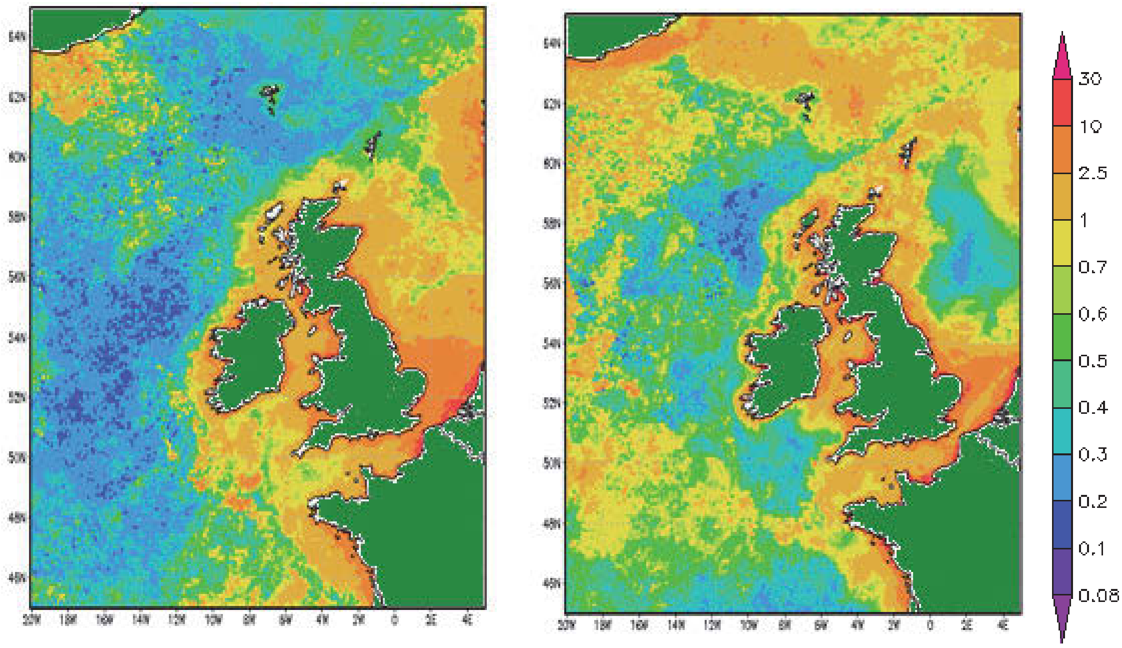
▲ Phytoplankton bloom off the Irish coast. (Image source: NASA)

Phytoplankton in the North East Atlantic

Phytoplankton have diverse roles, different spatial patterns and contrasting food value. Diatoms are the foundation of the copepod-fish food web, while dinoflagellates appear less valuable.

Changes in the relative abundance of phytoplankton have been linked to climate change and pollution.

Seasonal and spatial changes in phytoplankton for the North East Atlantic have been analysed based on over 100,000 Continuous Plankton Recorder (CPR) samples. The diatom bloom peaks first during May, with a smaller peak in summer. Dinoflagellates abundance reaches a peak in August. The blooms of both species start in the North Sea and spread outwards across the North East Atlantic region. (For further info see www.sahfos.ac.uk)



▲ Average Chl *a* concentration in spring (March to May) and Summer (June to August) 2013 in NWW indicating the distribution of phytoplankton – data obtained from Giovanni server

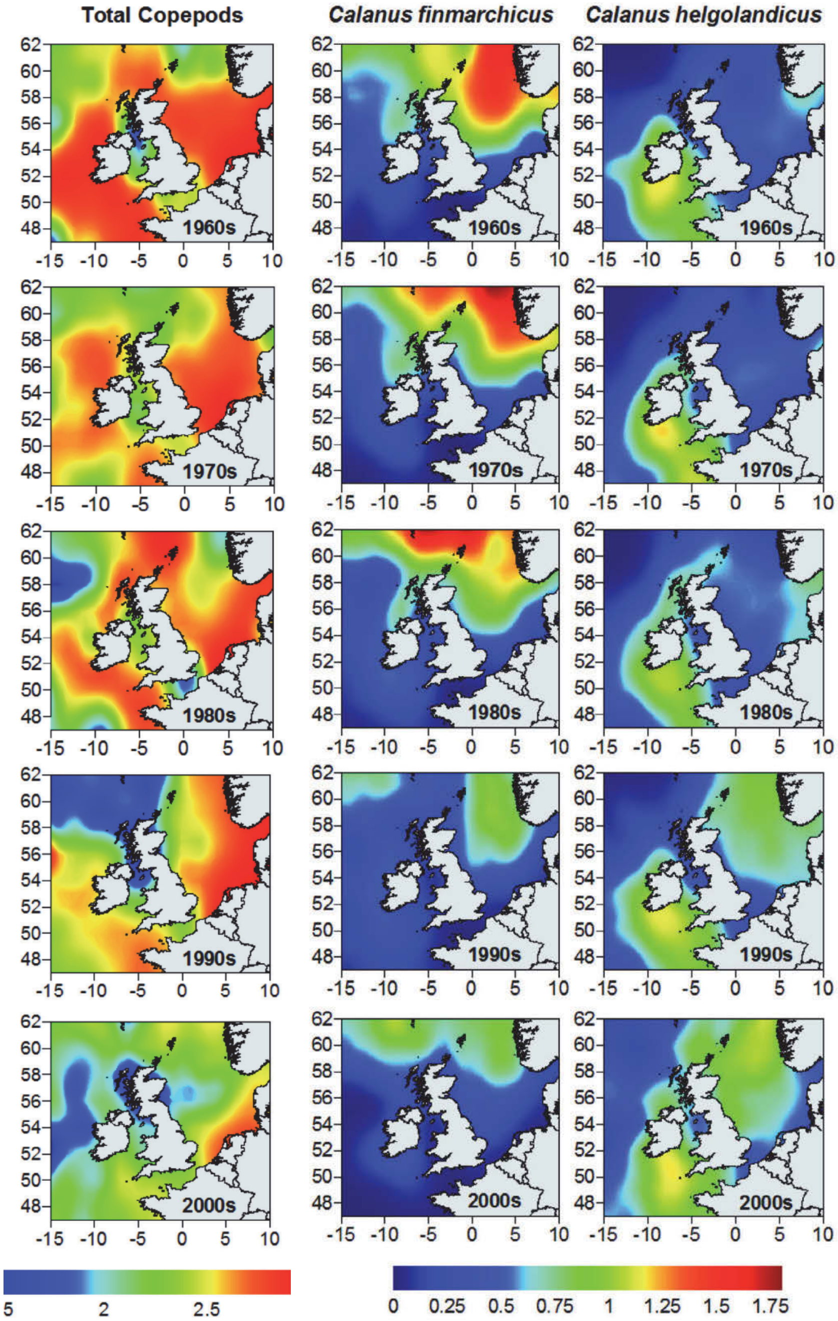
Harmful Algal Blooms

In temperate waters, phytoplankton blooms occur in spring, generally followed by smaller peaks in the autumn. The size of the bloom is determined by seasonal changes in light penetration and nutrient content of the water column through mixing and turbulence caused by winds. The bloom is followed by nutrient depletion as the phytoplankton consumes the available resources. Some of these blooms involve nuisance or noxious species and are described as Harmful Algal Blooms (HABs). Examples include those connected with Paralytic and Amnesic Shellfish Poisoning. HABs may be related to water surface temperatures in spring, as early seasonal stratification may favor phytoplankton growth in the water column. The red-tide forming species *Noctiluca scintillans* can naturally form extensive blooms during the summer period, in particular in the Irish Sea.

◀ Red tide on the West coast of Ireland.

Zooplankton

The zooplankton communities in the NWW are dominated by copepods, such as *Calanus finmarchicus* and *Calanus helgolandicus*, and they are an important prey item for many species at higher trophic levels. The two species have different geographical distributions, with *C. finmarchicus* more abundant in colder, more northern waters and *C. helgolandicus* more abundant in warmer, more southerly waters (although their ranges do overlap). The ratio between the warm-water species (*Calanus helgolandicus*) and a cold-water species (*Calanus finmarchicus*) is used as an indicator for climate change. Increases in regional sea temperatures have triggered a major northward movement of *Calanus helgolandicus* in the North-east Atlantic and a similar retreat of *Calanus finmarchicus* to the north (see figures below). Larger zooplankton includes Euphausiids (krill), Thaliacea (salps and doliolids) and Medusae (jellyfish).



◄ Mean decadal abundance of total copepods in the North-East Atlantic, measured from samples taken by the Continuous Plankton Recorder (left panel) and changes in the mean decadal abundance of *Calanus finmarchicus* and *C. helgolandicus* in the North-East Atlantic (centre and right panel). Source: Reid et al. 2010.

7

SEABIRDS

Key Points

The coastal and offshore waters of the NWW area provide local breeding and non-breeding seabirds, along with pelagic and passage migrants, with a rich source of nutrition, particularly near coastal upwelling and frontal systems.

Amongst locally breeding species, the NWW supports high proportions of the NW European population of the Roseate Tern, the European Storm-petrel, the Manx Shearwater and the Northern Gannet populations. Bird abundance can provide a good indicator of the state of the ecosystem due to the wide range of habitats which seabirds exploit and their high position in the food chain. The OSPAR EcoQO indicator on seabird population trends in NWW has been showing a declining trend since 2004.

Citizen science provides important contributions to our understanding of NWW seabird distribution and abundance. Special Protection Areas (SPAs) are designated for the protection of wild birds under the European Birds Directive. There are a large number of SPAs distributed along the coasts of NWW.

The seas and coastline of the NWW area are important for birds year round, with many areas being of international or national importance for the individual species or assemblages they support. The coastal and offshore waters of the NWW area provide local breeding and non-breeding seabirds, in addition to pelagic and passage migrants, with a rich source of nutrition, particularly near coastal upwelling and frontal systems (e.g. along the Irish Shelf front and north of the Porcupine Seabight).

Furthermore, the exposed and inaccessible west coasts of Ireland and Scotland provide perfect breeding habitats for many seabird species. Amongst locally breeding species, the NWW supports:

- approx. 93% (1400/1500 pairs) of the NW European population of Roseate Tern
- up to 30% of the World population of European Storm-petrel
- about 90% of the World Manx Shearwater population
- up to 67% of the Northern Gannet population
- most of Europe's Leach's Storm-petrels

▲ Kittiwake

A list of the abundant and rare seabirds and coastal birds found in the NWW area are given below. Information has been compiled by BirdWatch Ireland and is based on contributions by the public who train as sea bird observers and volunteer on platforms of opportunity as well as data collected on other monitoring programmes and scientific studies.

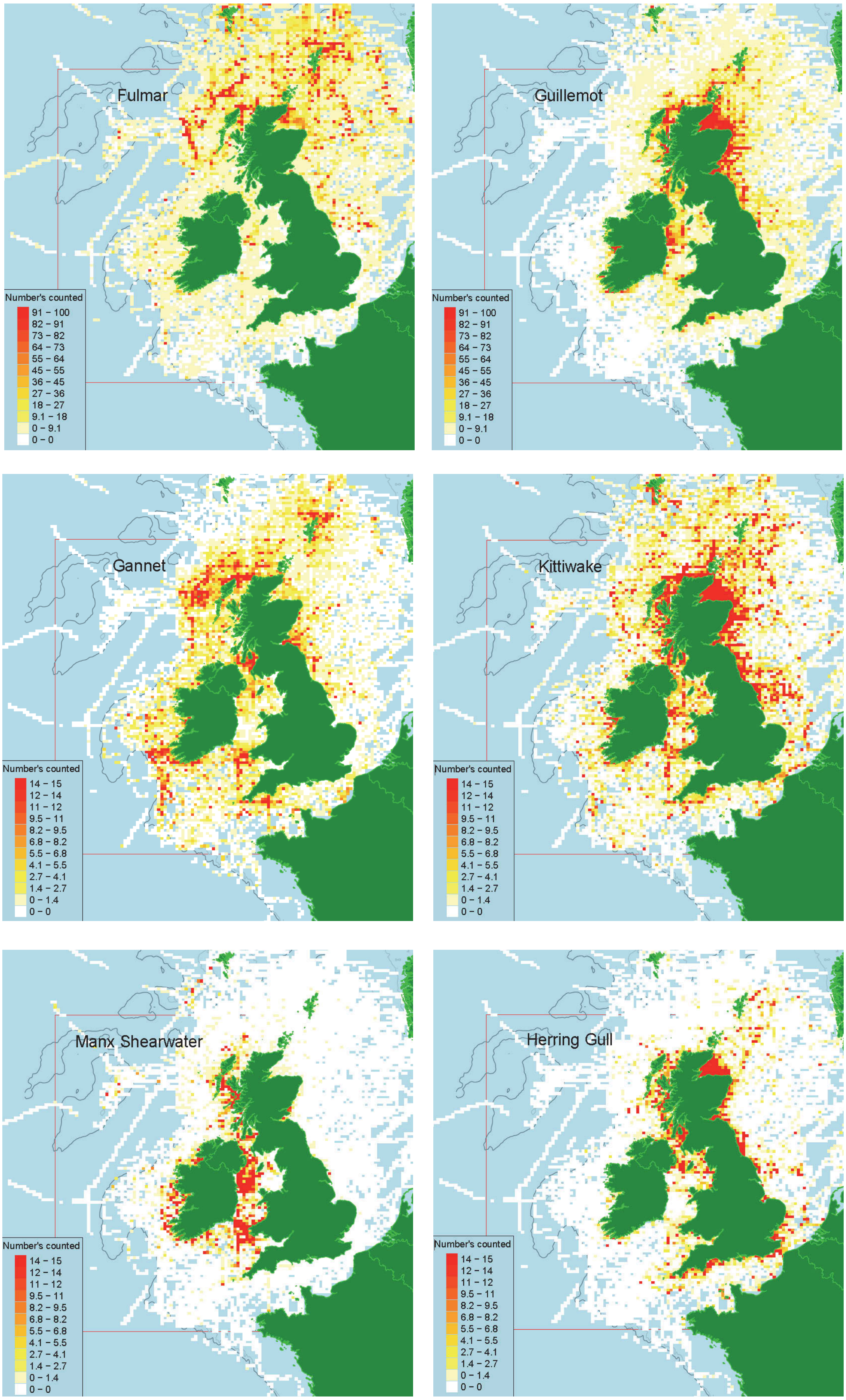
Citizen Science

Data on seabird sightings are collected by volunteers who train as seabird observers and join platform of opportunities, such as research vessels. Data collection is standardised and submitted to BirdWatchIreland.

Species	Breeding in NWW area	Passage migrant	Winter visitor
Common Scoter *Melanitta nigra*	(+)	+	++
Red-throated Diver *Gavia stellata*	++	+	++
Black-throated Diver *Gavia arctica*	[+]		+
Great Northern Diver *Gavia immer*		+	++
Black-browed Albatross *Thalassarche melanophris*		+ Rare	
Fulmar *Fulmarus glacialis*	++	++	++
Cahow (Bermuda Petrel) *Pterodroma cahow*		+ Rare	
Fea's / Zino's Petrel *Pterodroma feae / madeira*		+	
Cory's Shearwater *Calonectris diomedea*	(?)	++	
Great Shearwater *Puffinus gravis*		++	
Sooty Shearwater *Puffinus griseus*		++	+
Manx Shearwater *Puffinus puffinus*	++	++	+
Balearic Shearwater *Puffinus mauretanicus*		+	
Barolo Shearwater *Puffinus baroli*		+ Rare	
Wilson's Storm-petrel *Oceanites oceanicus*		+	
European Storm-petrel *Hydrobates pelagicus*	++	++	
Leach's Storm-petrel *Oceanodroma leucorhoa*	++	+	
Swinhoe's Storm-petrel *Oceanodroma monorhis*		+ Rare	
Gannet *Morus bassanus*	++	++	++
Cormorant *Phalacrocorax carbo*	++		++
Shag *Phalacrocorax aristotelis*	++		++
Red-necked Phalarope *Phalaropus lobatus*		+	
Grey Phalarope *Phalaropus fulicarius*		+	
Pomarine Skua *Stercorarius pomarinus*		++	
Arctic Skua *Stercorarius parasiticus*	[+]	++	
Long-tailed Skua *Stercorarius longicaudus*		++	
Great Skua *Stercorarius skua*	++	++	++
Puffin *Fratercula arctica*	++	+	+
Black Guillemot *Cepphus grylle*	++		++
Razorbill *Alca torda*	++		++
Little Auk *Alle alle*			+
Guillemot *Uria aalge*	++		++
Little Tern *Sternula albifrons*	+		
Black Tern *Chlidonias niger*		+	
Sandwich Tern *Sterna sandvicensis*	++	++	
Common Tern *Sterna hirundo*	++	+	
Roseate Tern *Sterna dougallii*	+	+	
Arctic Tern *Sterna paradisaea*	++	++	
Sabine's Gull *Xema sabini*		++	
Kittiwake *Rissa tridactyla*	++	++	++
Black-headed Gull *Chroicocephalus ridibundus*	++		++
Little Gull *Hydrocoloeus minutus*			+
Mediterranean Gull *Larus melanocephalus*	+		+
Common Gull *Larus canus*	++		++
Lesser Black-backed Gull *Larus fuscus*	++	++	+
Herring Gull *Larus argentatus*	++	+	++
Iceland Gull *Larus glaucoides*			+
Glaucous Gull *Larus hyperboreus*			+
Great Black-backed Gull *Larus marinus*	++		++

▲ Notes and key: + in small numbers; ++ common; [+] breeds Scotland but not Ireland; (+) restricted to freshwaters in breeding season; (?) possibly breeding SW Ireland, Information provided by BirdWatch Ireland.

Spatial historic seabird data for 1979-2000 show some of the most common species encountered in NWW were the Northern Fulmar, Manx Shearwater, Northern Gannet, common Guillemot and the Black Legged Kittiwake (data from ESAS database).



▲ Distribution of most abundant sea birds in NWW-1980-2000 (source: European Seabird at sea database ESAS http://seamap.env.duke.edu).

The **Northern Fulmar** is a common resident along British and Irish coastlines, whose breeding range has expanded rapidly in the northeast Atlantic during the last century. This highly pelagic seabird is frequently recorded and a very widespread species, being recorded throughout the NWW area during all seasons.

The **Common Guillemot** is the largest of the four auk species that breed in Britain and Ireland. The most widespread of all auk species, its population size has continued to fluctuate in response to a combination of human-related and natural events. The main stronghold of the local breeding population is located in Shetland, Orkney and Scotland.

▲ Northern Fulmar

The **Northern Gannet** is the largest of Europe's seabirds. This prominent species, widely known for its spectacular diving behaviour, breeds on both mainland cliffs and remote islands off Scotland and Ireland. British and Irish colonies support approximately 67.5% of the world's growing breeding population.

The **Black-legged Kittiwake** is a small, cliff-nesting gull species that breeds along much of the British and Irish coastlines. It is the most pelagic of the local gull species especially during the winter when birds disperse to the Bay of Biscay, the North Sea and westward to the northern Atlantic.

The **Manx Shearwater** is a common local breeder and passage migrant that are regularly recorded between March and October. The breeding distribution of this long distance migrant is largely restricted to northwestern Europe, where the largest concentrations are located along the west coasts of Britain and Ireland.

The **Herring Gull** is a common resident within North Western Waters, it breeds across Europe. The largest concentrations are seen in North of Soctland.

▲ Northern Gannett

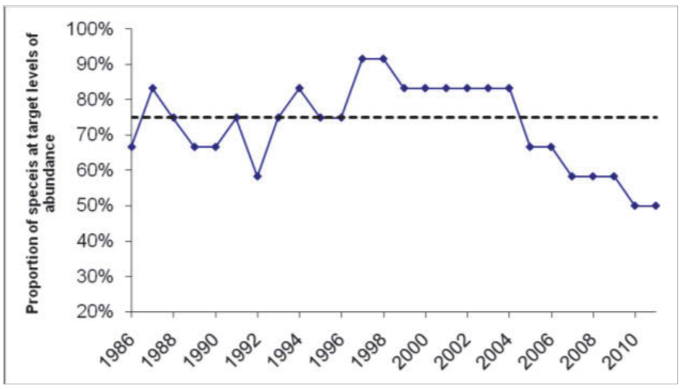
Interaction between seabirds and fisheries occurs directly and indirectly. Direct interactions include incidental bycatch, while indirect interactions occur through resource competition, modification and/or loss of essential habitat and disturbance. For the NWW waters, seabird bycatch has been demonstrated for bottom and midwater trawl fisheries as well as longline, trammel and gillnet fisheries (ICES, 2013). Effects on population sizes are not fully evaluated.

Indicators of Ecosystem Health

Bird abundance can provide a good indication of the state of the ecosystem due to the wide range of habitats which they exploit and their high position in the food chain. Changes in the abundance of their prey at lower trophic levels can have major impacts on bird populations.

The ecological quality objective (EcoQO) indicator on breeding seabird population trends in NWW includes data from 1986–2012 on thirteen species (Northern fulmar, European shag, herring gull, great black-backed gull, black-legged kittiwake, Sandwich tern, common guillemot, razorbill, Arctic skua, great cormorant, little tern, common tern, and roseate tern).

The indicator shows a declining trend since 2004 and ICES has advised that the ECO QO target has not been met since 2005 (ICES 2013). Arctic skua, Northern fulmar, European shag, roseate tern, and black-legged kittiwake have failed to meet their targets and/or are in decline.



◀ The percentage of seabird species in NWW that were within target levels of abundance during 1986–2012. The EcoQO was not achieved in years when the percentage dropped below 75% (ICES, 2013).

Species	English name	2012
Fulmarus glacialis	Northern fulmar	↓
Stercorarius parasiticus	Arctic skua	↓↓
Phalacrocorax carbo	Great cormorant	↓
Phalacrocorax aristotelis	European shag	↓↓
Larus argentatus	Herring gull	↓
Larus marinus	Great black-backed gull	↓
Rissa tridactyla	Black-legged kittiwake	↔
Sternula albifrons	Little tern	↑
Sterna dougalii	Roseate tern	↑
Sterna hirundo	Common tern	↓
Sterna sandvicencis	Sandwich tern	↓
Alca torda	Razorbill	↑
Uria aalge	Common guillemot	↓

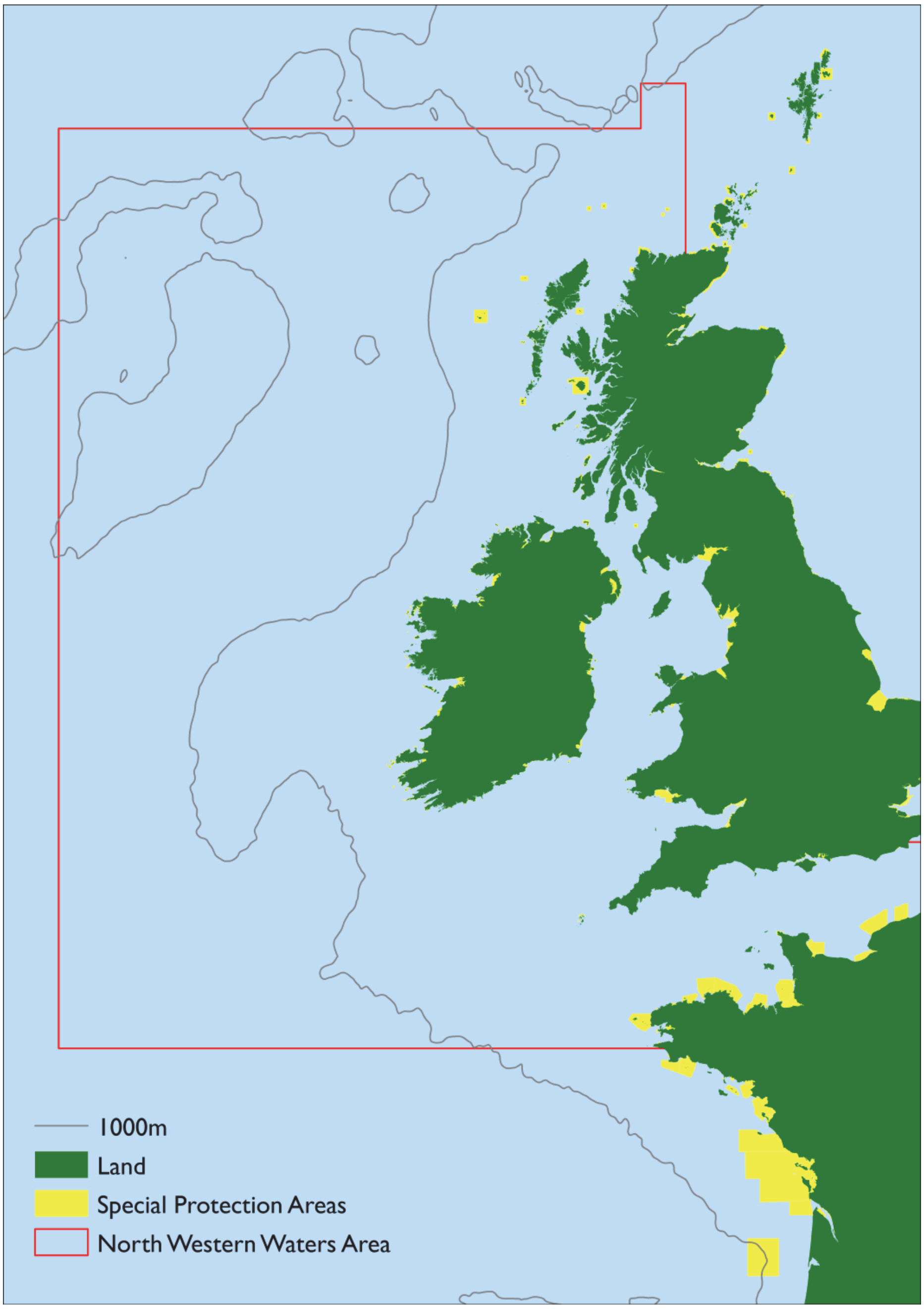
Key :

Population trend in previous ten years	
↑↑	strong increase (>5% p.a.)
↑	weak increase (2–5% p.a.)
=	no change (< 2% p.a.)
↓	weak decrease (2-5% p.a.)
↓↓	strong decrease (>5% p.a.)
Relative abundance	
	≤ 70% or ≤ 80%
	>70 or >80%, and ≤ 130%
	>130%

◄ Bird population abundance trends in NWW. Analysis is based on data collected as part of the UK and Ireland's Seabird Monitoring Programme (SMP). Note that most colonies in NWW are not surveyed in each year of the time-series. Arrows present trends over the last 10 years while colours indicate relative abundance compared to species specific target levels. Green cells = target met; orange cells = target met but relative abundance exceeded 130%; red cells = target not met (from ICES 2013).

Protection of birds under the European Birds directive:

The Birds Directive 2009/147/EC aims to protect all wild bird species naturally occurring in the Union and there are a large number of coastal sites designated for the protection of coastal and marine birds in NWW. These are called Special Protection Areas or SPAs.



▲ Special Protection Areas (SPAs) designated under the Birds directive in NWW

(GIS source: EEA, http:/eea.europe.eu).

MARINE REPTILES

KEY POINTS

The leatherback turtle is regularly seen in NWW and while they are reported in every month, sightings peak from June to October. They breed in tropical areas and are the only species of marine turtle to have developed adaptations to life in cold water.

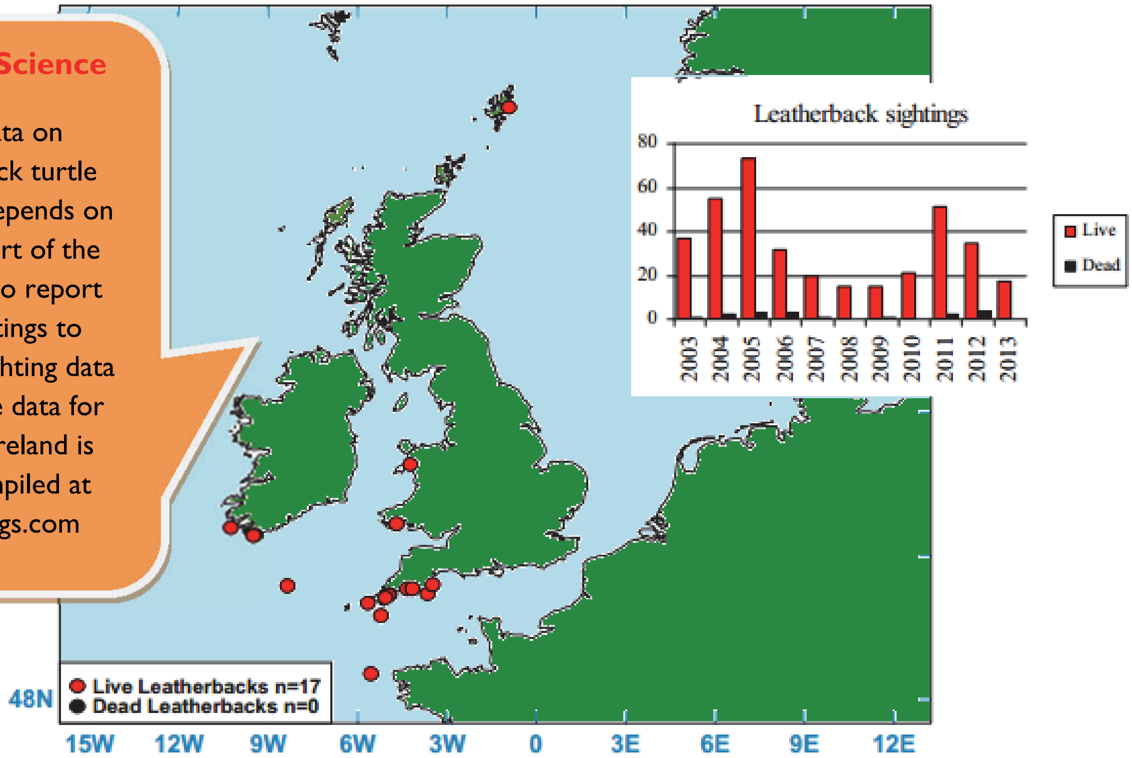
Leatherbacks are one of the few predators which forage almost exclusively on gelatinous zooplankton. In NWW leatherback sightings have recently been linked to areas of high jellyfish abundance. Foraging on such a temporally and spatially sporadic prey is the primary driving force behind the annual migration of leatherbacks.

Leatherback populations in the Atlantic are considered to be stable. The data on leatherback turtle sightings depends on the support of the public, who report of any sightings to national sighting data bases.

The main marine reptile species recorded from NWW are marine turtles. Five species of marine turtle have been recorded in UK and Irish waters. However, only one species, the Leatherback turtle (*Dermochelys coriacea*), is reported annually and is considered a regular and normal member of NWW marine fauna. Loggerhead turtles *Caretta caretta* and Kemp's ridley turtles *Lepidochelys kempii* occur less frequently, with most specimens thought to have been carried north from their usual habitats by adverse currents. Records of two other vagrant species, the Hawksbill turtle *Eretmochelys imbricata* and the Green turtle *Chelonia mydas* are very rare. Turtles are protected under the EU Habitats Directive (EU Council Directive 92/43/EEC).

Citizen Science

The data on leatherback turtle sightings depends on the support of the public, who report any sightings to national sighting data bases. The data for UK and Ireland is then compiled at strandings.com



Leatherback turtle sightings for Ireland and the UK 2013
(Source: Penrose and Gander 2014 - http:// www.strandings.com)

Leatherback Turtle

The leatherback turtle is the largest marine turtle that occurs in warm waters and has been regularly recorded in the NWW area. They breed in tropical areas, but range widely to forage temperate and boreal waters outside the nesting season. They are the only species of marine turtle to have developed adaptations to life in cold water. Long-distance migration has been documented from tag returns and more recently using satellite telemetry. There are distinct seasonal peaks in the occurrence of leatherback turtles in northern waters. Around Irish and UK waters, most sightings are reported between August and October but they have been recorded in every month.

MARINE MAMMALS

Key Points

Cetaceans and seals are the main marine mammals found in NWW. The NWW is an area of particularly high species richness for cetaceans. To date 24 cetacean species have been recorded in Irish and UK waters. This species richness can be attributed to the availability of prey and high productivity along the Atlantic margin of the NWW, which is caused by a warm oceanic current called the North Atlantic Drift. Many cetaceans breed in NWW while others use the area as a migration route.

Key data sets on cetacean sightings are collected by the public, who volunteer as marine mammal surveyors and join platforms of opportunity, such as research vessels and ferries.

The grey and harbour, or common, seals are the two species of pinniped most common in NWW area. Both species have established themselves in terrestrial colonies along the coastlines of Ireland and the UK. They leave these areas when foraging or moving between areas and return for pupping and molting. The walrus is a visitor to NWW area.

Cetaceans

The NWW area is very important for a wide range of cetacean (whales, dolphins and porpoise) species. There is substantial background evidence promoting the Atlantic Margin as an area of high species richness for cetaceans. To date 24 cetacean species have been recorded in Irish and UK waters. The majority of these have been recorded from sightings, strandings and acoustic recordings.

Breeding in NWW has been confirmed for a number of cetacean species including harbour porpoise (*Phocoena phocoena*), common (*Delphinus delphis*), bottlenose (*Tursiops truncates*), Risso's (*Grampus griseus*), white sided (*Lagenorhynchus acutus*) and white-beaked (*L albirostris*) dolphins and pilot whale (*Globiocephala melas*), while other species such as bottlenosed (*Hyperoodon ampullatus*) and minke whale (*Balaenoptera acutorostrata*) are also suspected of breeding.

Many cetacean species are not known to breed in the NWW but migrate annually along the western seaboard. Recent data suggests that some of these species feed year-round in NWW, including the fin whale (*Balaenoptera physalus*) and humpback whale (*Megaptera novaeangliae*), whereas others may over-winter in waters south of Ireland (e.g. blue whale *Balaenoptera musculus*).

▲ Humpback whale breaching off the south east coast of Ireland.

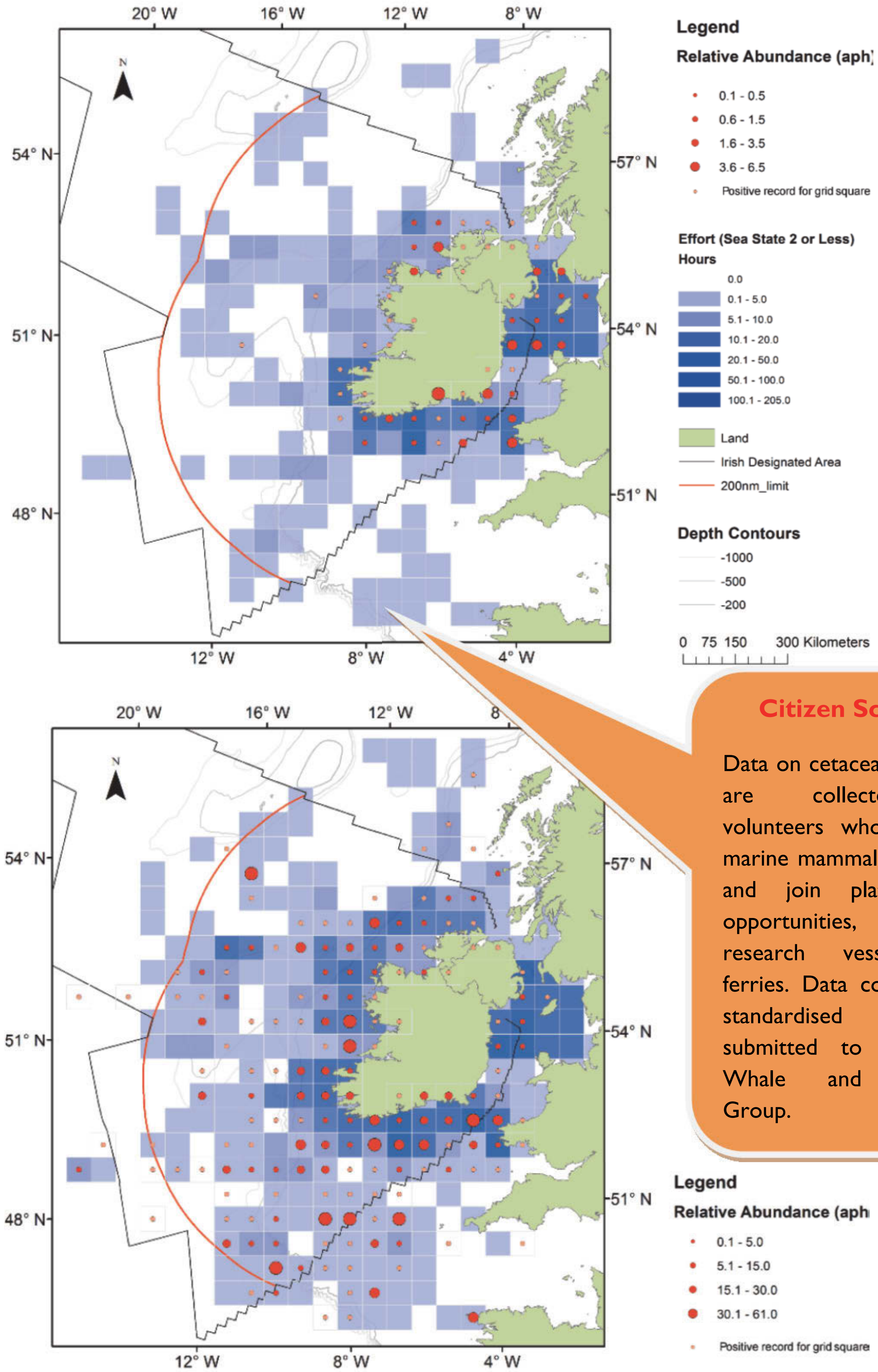
Cetacean Abundance and Distribution

There are a number of key factors that determine cetacean distribution and abundance in NWW. These are likely to include:

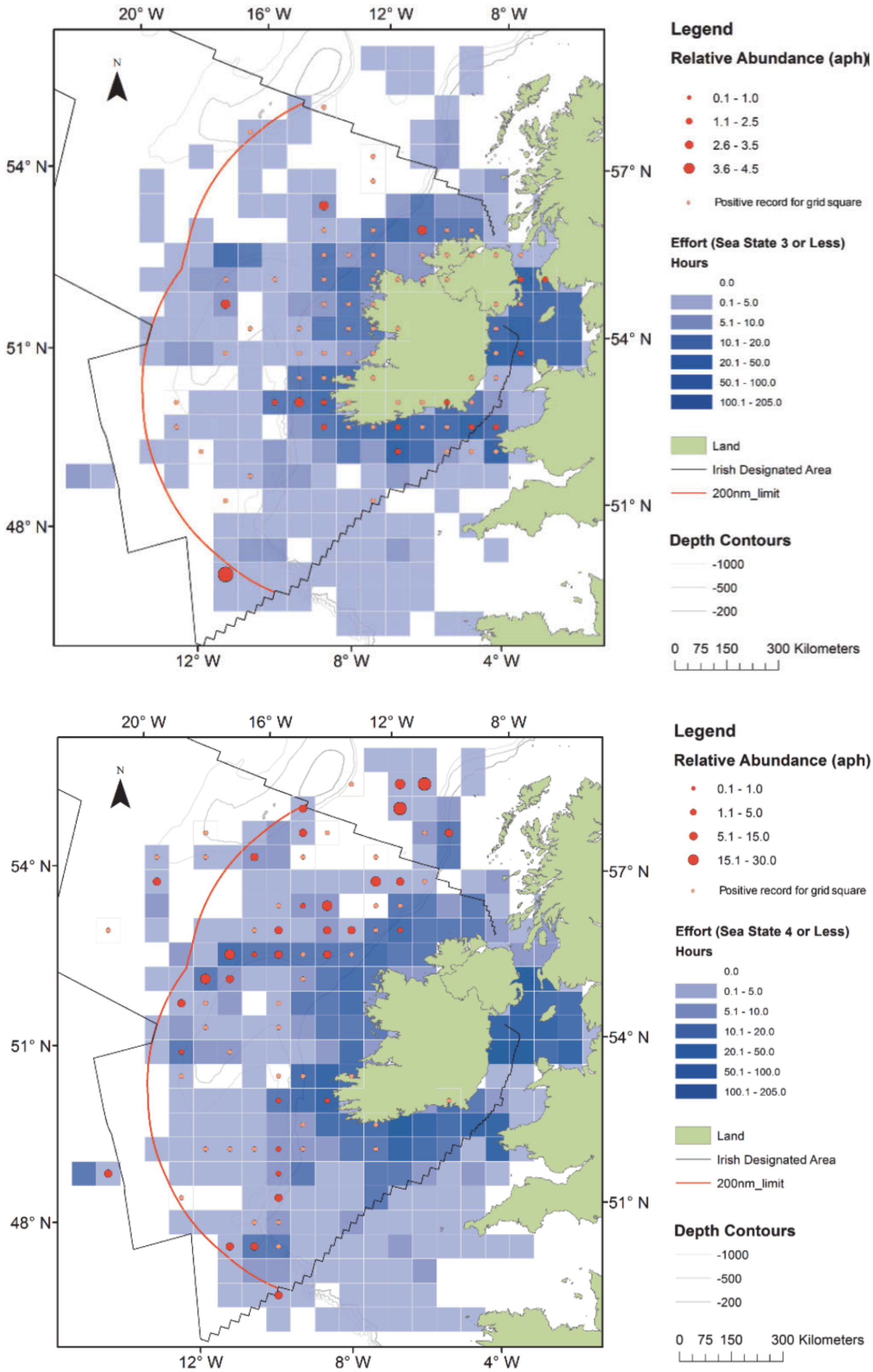
- The availability and distribution of prey
- the North Atlantic Drift, a warm oceanic current meeting the western European continental shelf giving areas of seasonally high productivity along the Atlantic margin of the NWW.
- Seabed bathymetry whereby areas of complex bathymetry support deep diving species (e.g. beaked whales)

Citizen Science

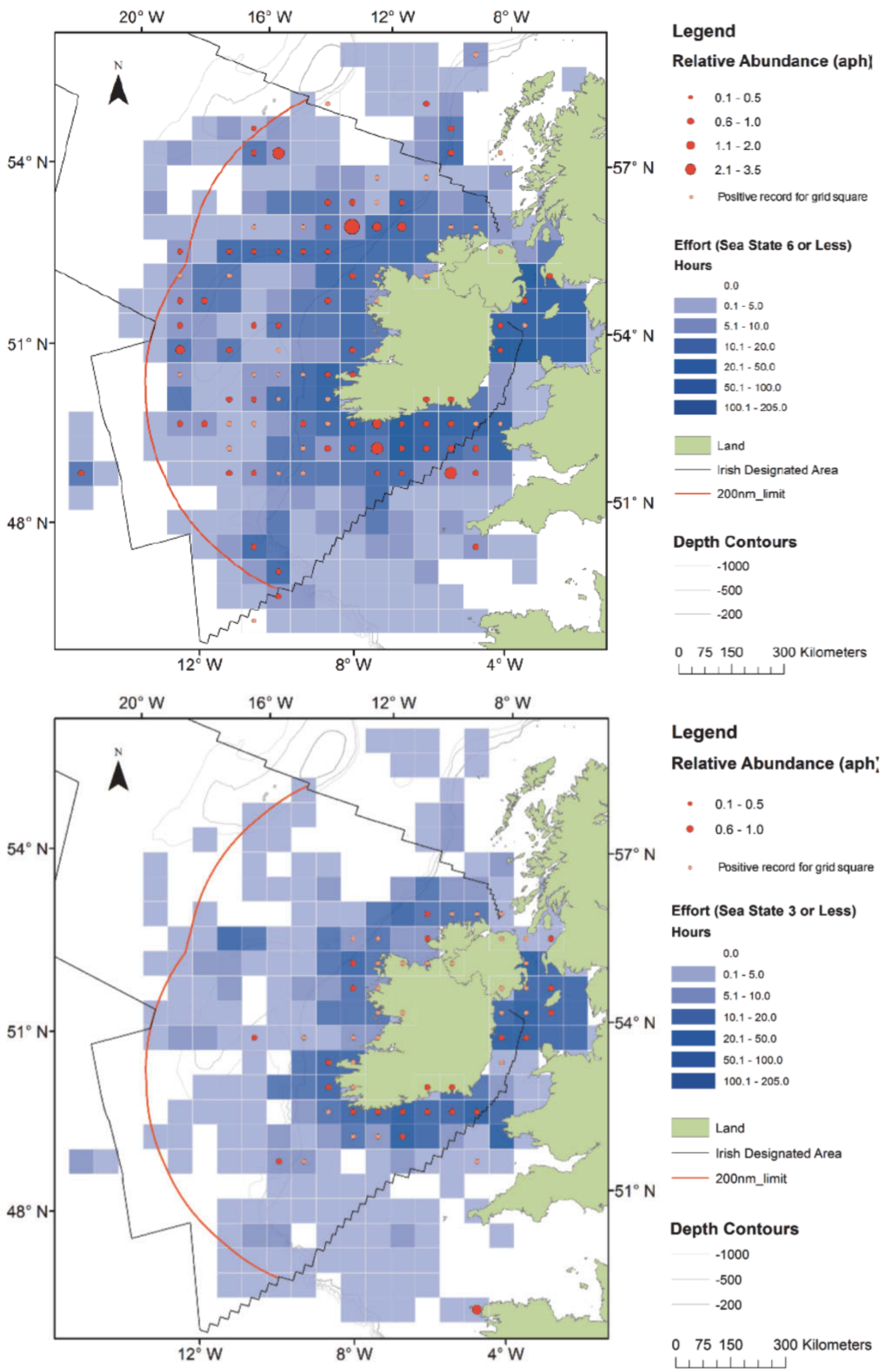
Data on cetacean sightings are collected by volunteers who train as marine mammal surveyors and join platform of opportunities, such as research vessels and ferries. Data collection is standardised and is submitted to the Irish Whale and Dolphin Group.



▲ Distribution and relative abundance of harbour porpoises (upper panel) and short-beaked common dolphins (lower panel) within the Irish EEZ 2005-2011 (from Wall *et al.*, 2013, see www.IWDG.ie).



▲ Distribution and relative abundance of bottlenose dolphin (upper panel) and long finned pilot whale (lower panel) within the Irish EEZ 2005-2011 (from Wall *et al.,* 2013, see www.IWDG.ie).

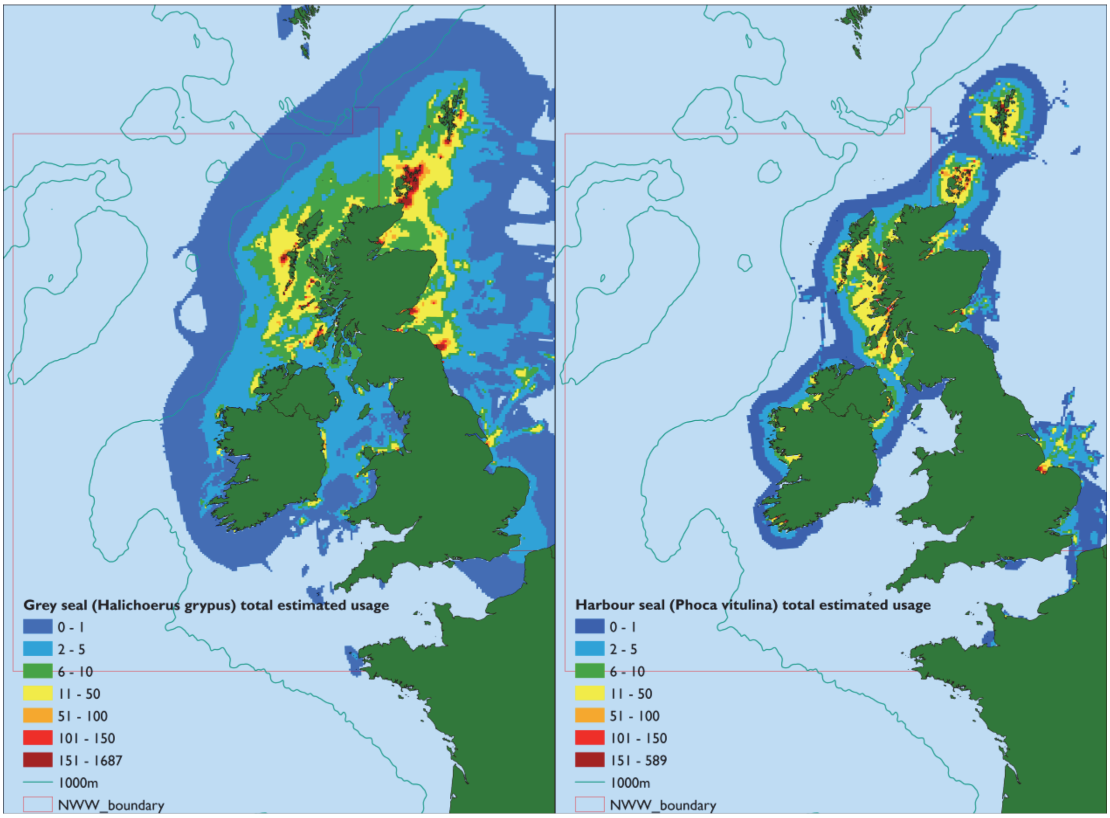


▲ Distribution and relative abundance of fin whales (upper panel) and minke whales (lower panel) within the Irish EEZ 2005-2011 (from Wall *et al.,* 2013, see www.IWDG.ie).

▲ Grey Seal Mother and Pup

Seals

The grey (*Halichoerus grypus*) and harbour, or common, seal (*Phoca vitulina*) are the two most common pinniped species in NWW. Both species have established themselves in terrestrial colonies (haul out sites) along the coastlines of Ireland and the UK. They leave these areas when foraging or moving between areas and return ashore for pupping, rearing their young and molting.



▲ Distribution at sea of grey seals (left) and harbour seals (right) around Ireland and Britain based on telemetry data from 1991 - 2011 for grey seals and 2001 - 2012 for harbour seals and count data from 1988-2012 (Jones et al. 2013).

Grey Seals

Grey seals are found across the North Atlantic Ocean and in the Baltic Sea. Approximately half of the world's population occurs in the northeast Atlantic. Most of the grey seal population will be on land for several weeks from October to December during the pupping and breeding season, and again in February and March during the annual moult. Densities at sea are likely to be lower during this period than at other times of the year. They also haul-out and rest throughout the year between foraging trips to sea. Studies at two Scottish colonies have indicated that breeding females tend to faithfully return to their natal breeding colony for most of their lives. Mature females give birth to a single pup which is nursed for about three weeks before it is weaned and moults into its sea-going adult coat. Grey seal pups tagged in the UK have been recaptured or recovered along the North Sea coasts of Norway, France and The Netherlands, mostly during their first year.

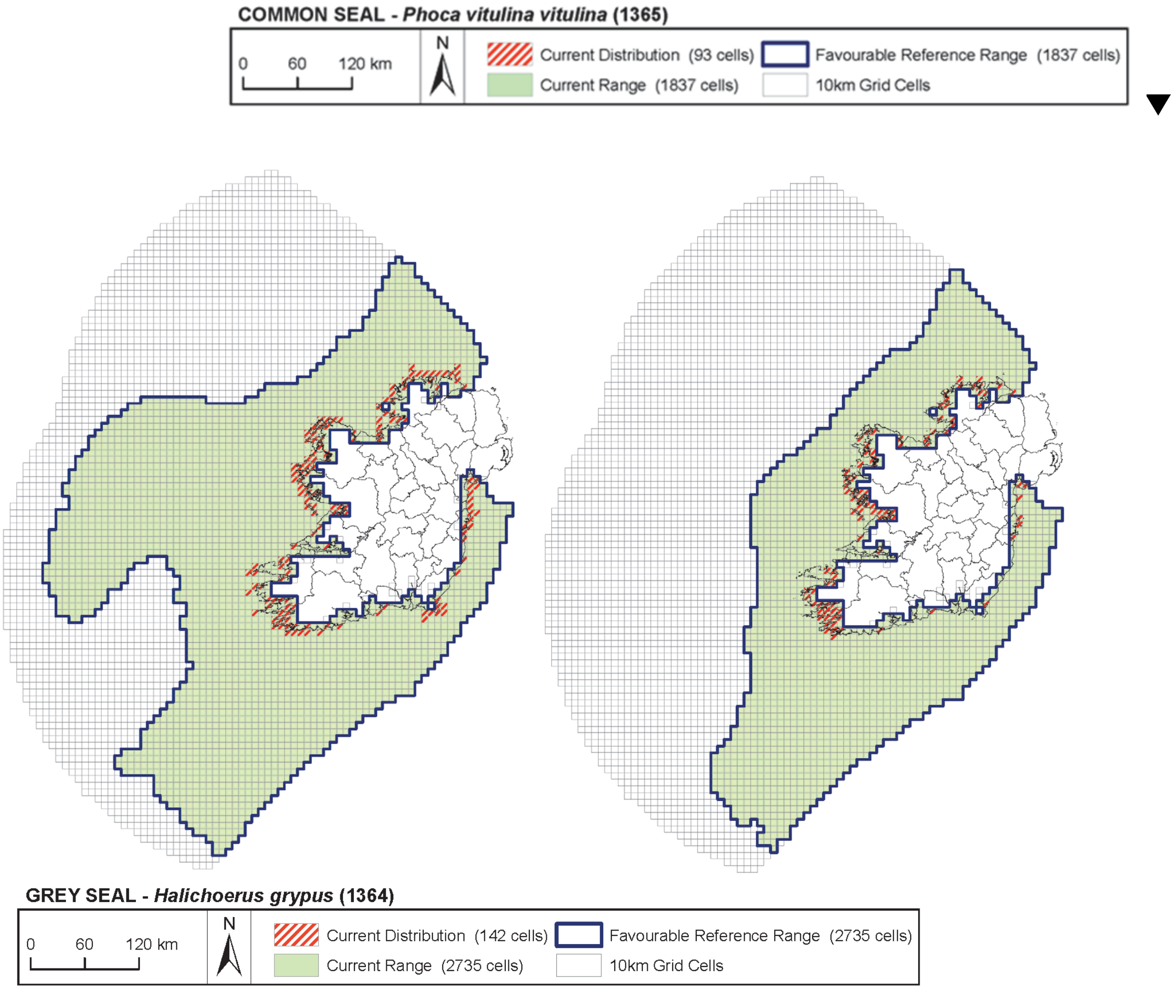
▲ White coated Grey Seal

Harbour Seals

Harbour (or common) seals are one of the most widespread pinniped species and have an almost circumpolar distribution in the Northern Hemisphere. Around Britain and Ireland, harbour seals haul out on tidally exposed areas of rock, sandbanks or mud. Pupping occurs on land from June to July, while the moult is centred around August and extends into September. Therefore, from June to September harbour seals are ashore more often than at other times of the year. In the UK, the largest concentrations are found in Scotland, primarily on Orkney, Shetland and the Inner and Outer Hebrides. Many other haul-out sites supporting lower numbers are present around the UK coast, the largest of which are found in the Moray Firth, the east coast of Northern Ireland, the Firths of Tay and Forth, and southwest Scotland. Common seals are widespread throughout coastal waters surrounding these haul-out sites. Their distribution at sea is constrained by the need to return periodically to land. Although harbour seals seem to show some fidelity to particular haul-out sites, they occasionally make rapid, relatively long-distance movements to other locations.

Seal Diet

Grey seal diet is dominated by fish species. The fish species composition of the diet varies both spatially and temporally. In studies carried out on grey seals in the Hebrides, sandeel, cod and haddock were dominant in the diet. In the southwestern area of NWW, hake, pollack and monkfish have shown high levels of depredation by seals in pilot studies. The interaction between seals and fish stocks is complex and poorly understood.



▲ Distribution areas of grey seals (left) and harbour or common seal (right) within the Irish EEZ (NPWS, 2013).

10

Basking shark (*Cetorhinus maximus*) Image source: SuperStock.co.uk

SHARKS, SKATES AND RAYS

Key Points

Sharks, skates and rays belong to a group of fish called elasmobranchs that have cartilaginous skeletons. Due to their reproductive biology, elasmobranchs are particularly vulnerable to over-exploitation.

In 2013, 18,600 tonnes of elasmobranchs were landed in NWW. There has been a substantial decrease in landings over the last decade due to declining stocks and increased regulations.

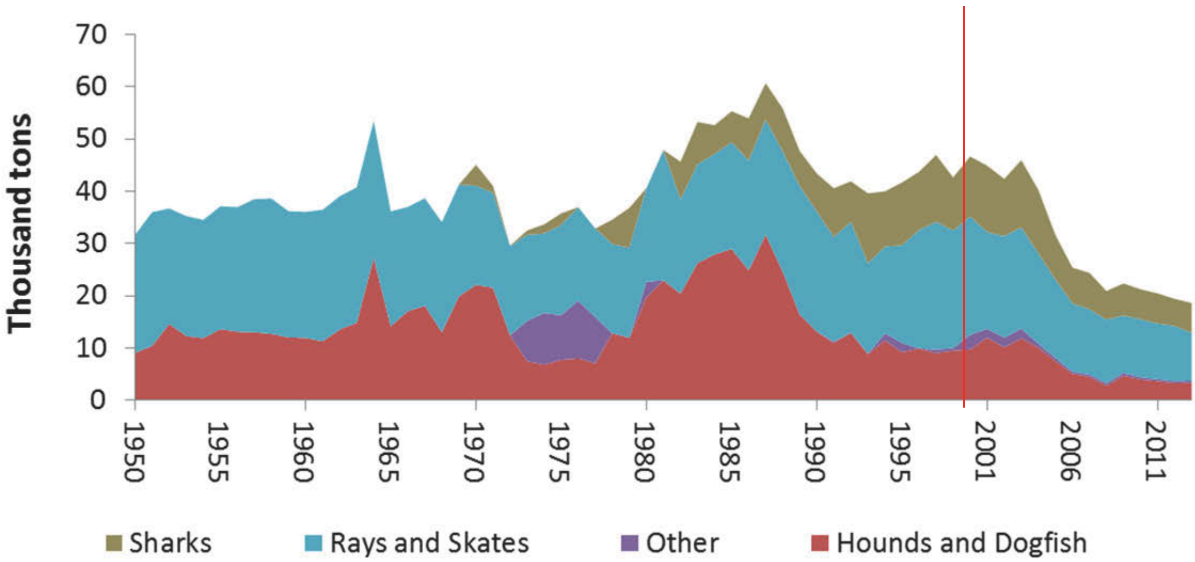
Important nursery areas for sharks, skates and rays exist in NWW. The recordings of eggcases or “mermaids purses” contribute to the understanding of where these areas are located.

The EU Action plan for the Conservation and Management of Sharks aims to protect sharks through improved knowledge, sustainable fisheries and coherence in policies.

Sharks, skates and rays belong to a group of fish called elasmobranchs. The defining characteristic is a skeleton made of cartilage (rather than bone as with other fishes).

Elasmobranchs generally produce a handful of offspring per reproductive cycle but invest a greater amount of energy and resources in each one. This, however, makes them far more vulnerable to over-exploitation in comparison to most broadcast spawning bony-fishes. NWW contain populations of some elasmobranch species listed as critically endangered (Angel Shark) and vulnerable (Porbeagle and Common Smooth-hound) by the IUCN.

The total landings of sharks, skates and rays have declined substantially over the last decade. This is mainly due to declining stocks and increased restrictions but changing consumer preferences have also played a role. The graph below shows this trend in various groups but it should be stressed that this shows landings only and not discarded bycatch.

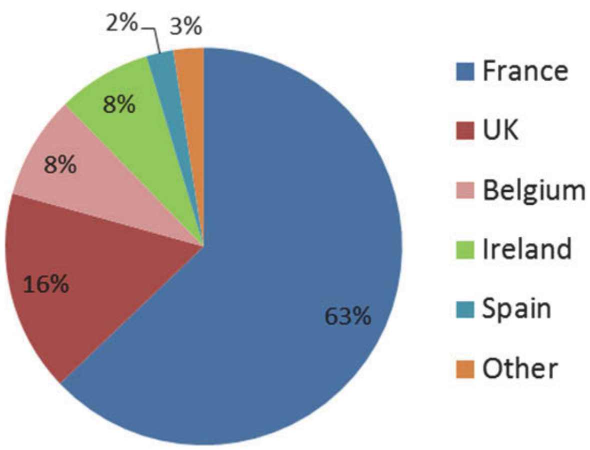


▲ Landings of elasmobranchs in NWW from 1950-2013 (ICES Catch Statistics from FAO FishStat Plus).
Note: 1999 data omitted due to missing French data (red line). "Other" may contain some fishes that are not elasmobranchs but have cartilaginous skeletons, e.g. chimeras

In NWW, most elasmobranchs are taken as bycatch in commercial mixed fisheries. The directed fisheries are mainly for skates and rays in Division VIIa. Recreational fisheries, including charter angling, may be an important component of the tourist industry in some areas.

Portuguese dogfish and Leafscale gulper sharks are two species of deepwater elasmobranchs found in NWW. Trawlers, longliners and gillnetters in Sub Areas VI and VII were the fleets targeting these species. However, since 2003, reported landings have declined due to stock depletion and the introduction, and gradual reduction, of EU TACs and quotas in response to ICES advice, which has been a zero TAC since 2010. Deep-water sharks do, however, continue to be taken as by-catch in a mixed deepwater trawl fishery in Sub Areas VI and VII (ICES Advice 2012).

Total Elasmobranch Landings in NWW 2013: 18.6k tonnes



▲ Total Elasmobranch Landings by country in NWW for 2013 (ICES Catch Statistics from FAO FishStat Plus)

France, UK, Ireland and Belgium land the highest numbers of elasmobranchs in NWW, together accounting for 95% of the 18,600 tonnes caught in 2013.

EU Action plan for the Conservation and Management of Sharks

The EC has set up a plan for the Conservation and Management of Sharks in 2009 with three objectives:

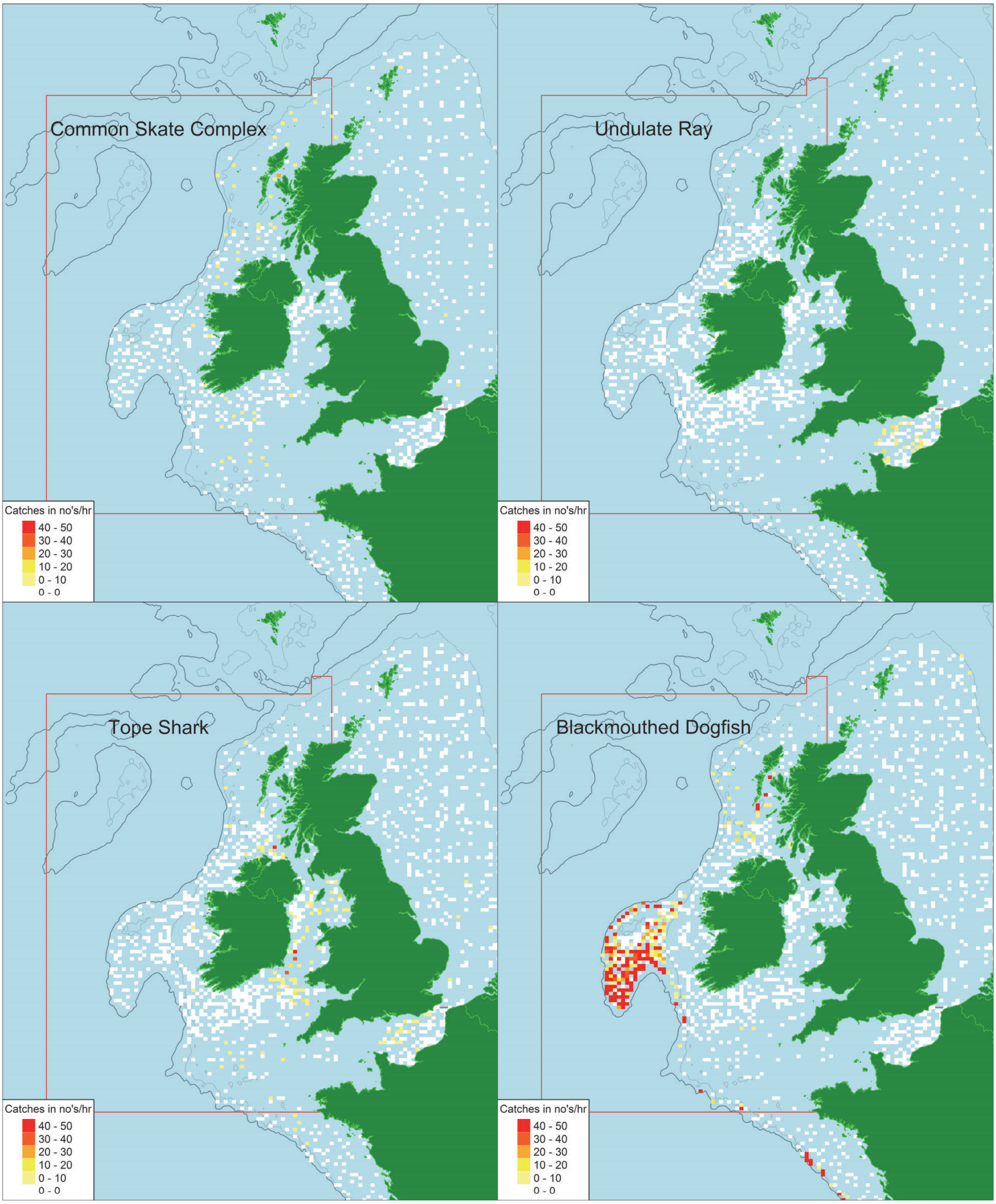
- deepen knowledge both on shark fisheries and on shark species and their role in the ecosystem;
- ensure that directed fisheries for shark are sustainable and that their by-catches are properly regulated;
- encourage a coherent approach between the internal and external EC fishery policy for sharks.

The plan is based on the international action plan for sharks as developed by FAO. It is voluntary but all EU Member States concerned are encouraged to implement it.

The distribution of skates and rays as well as other demersal elasmobranchs can be derived with catch data, compiled from the international bottom trawl survey, coordinated by ICES (ICES 2014). The following maps show the catch rates (kg h^{-1}) of some of the common and rarer demersal elasmobranches residing in NWW. The maps indicate that some species have distinct distribution patterns, e.g. undulate ray, while others are more ubiquitous (lesser spotted dogfish).

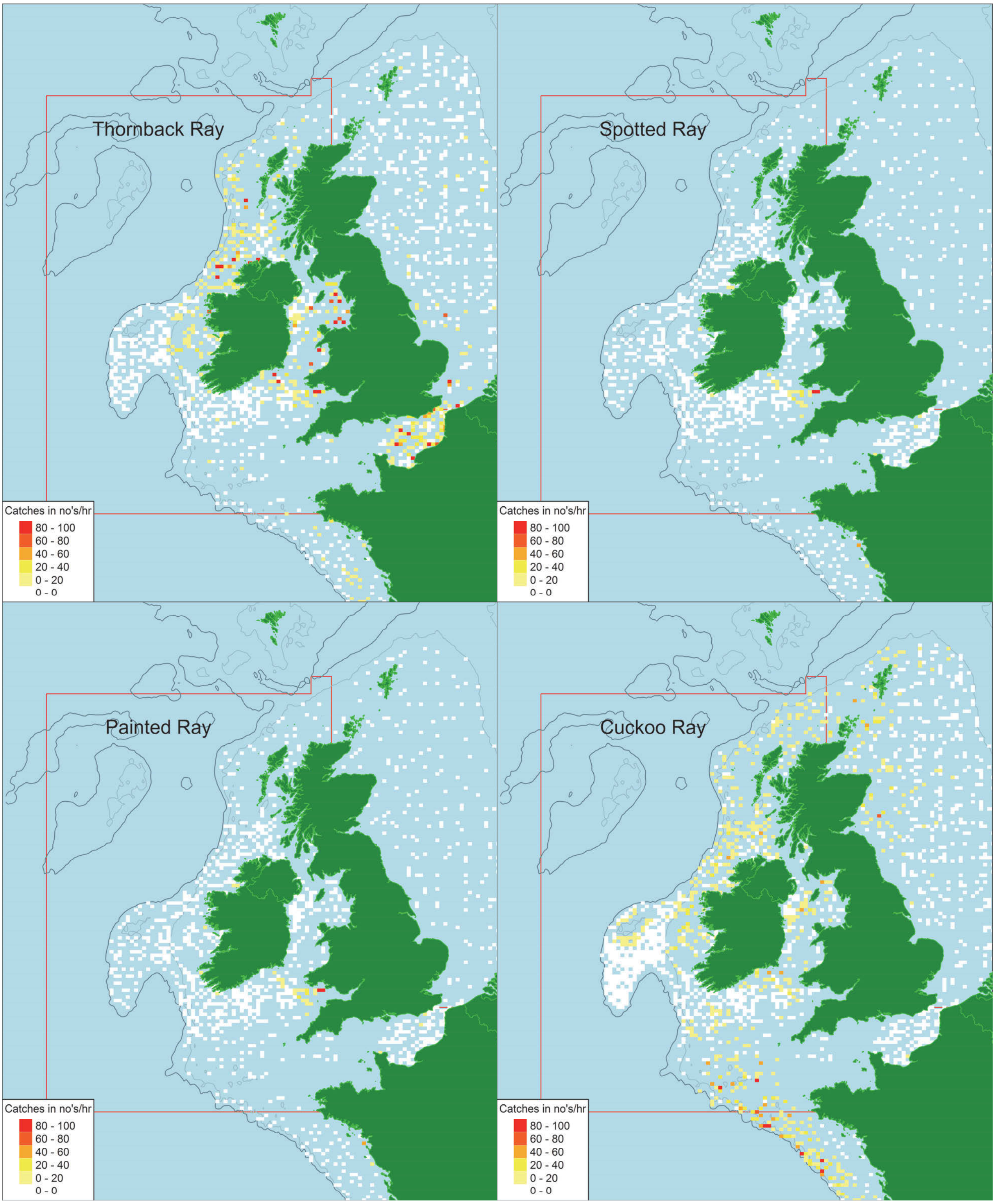
The knowledge on elasmobranch distribution, esp. nursery grounds is also improved through the sightings of their eggcases. Important data on elasmobranch egg cases are collected by the public, who report any sightings of *mermaid's purses* to a central data base (Purse Search Ireland at: www.marinedimensions.ie).

Elasmobranch Distribution in NWW



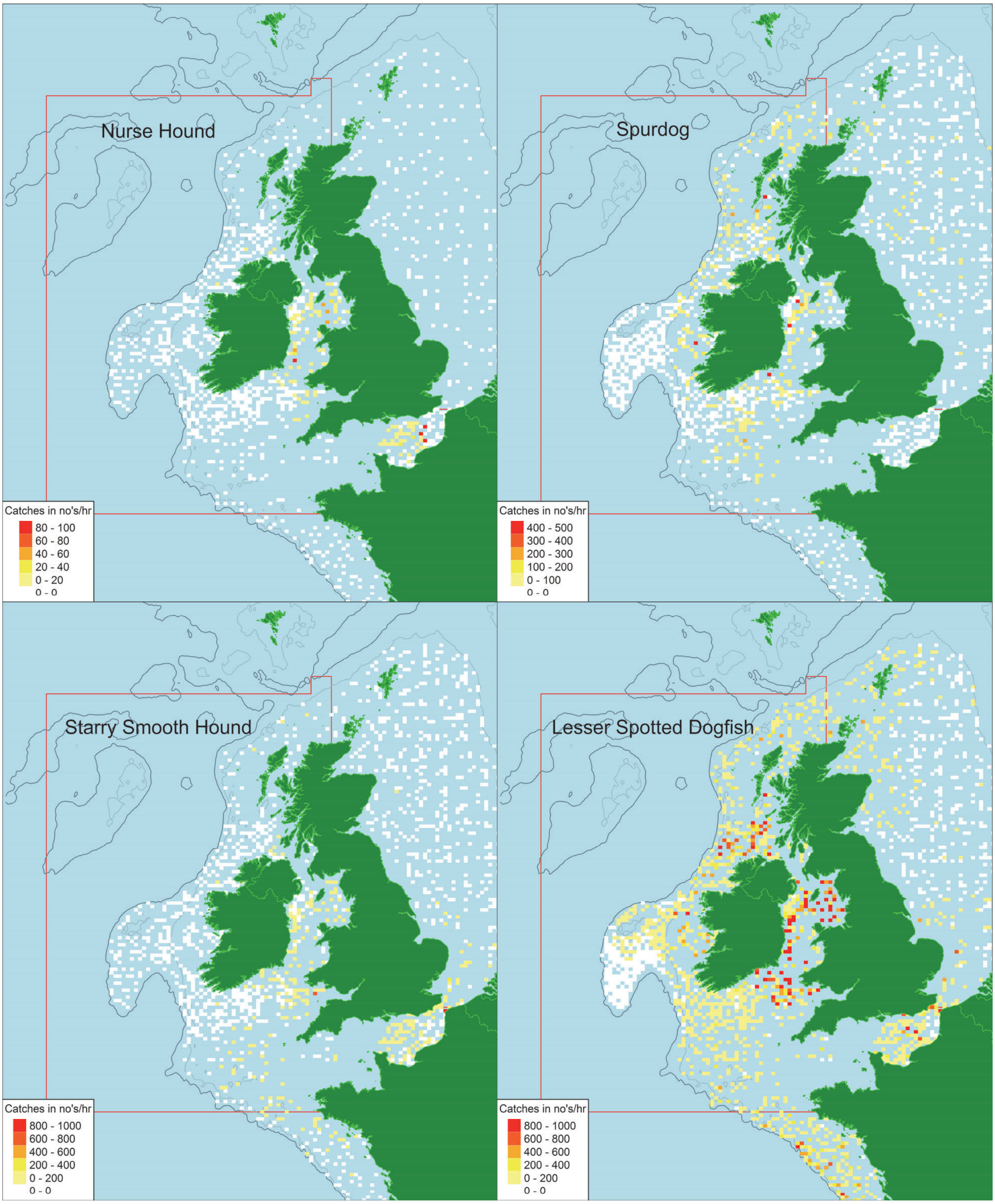
▲ Distribution of elasmobranches commonly caught in NWW based on catch rates from the 2013 data of the international bottom trawl survey (Data from ICES.dk).

Elasmobranch Distribution in NWW



▲ Distribution of elasmobranches commonly caught in NWW based on catch rates from the 2013 data of the international bottom trawl survey (Data from ICES.dk).

Elasmobranch Distribution in NWW

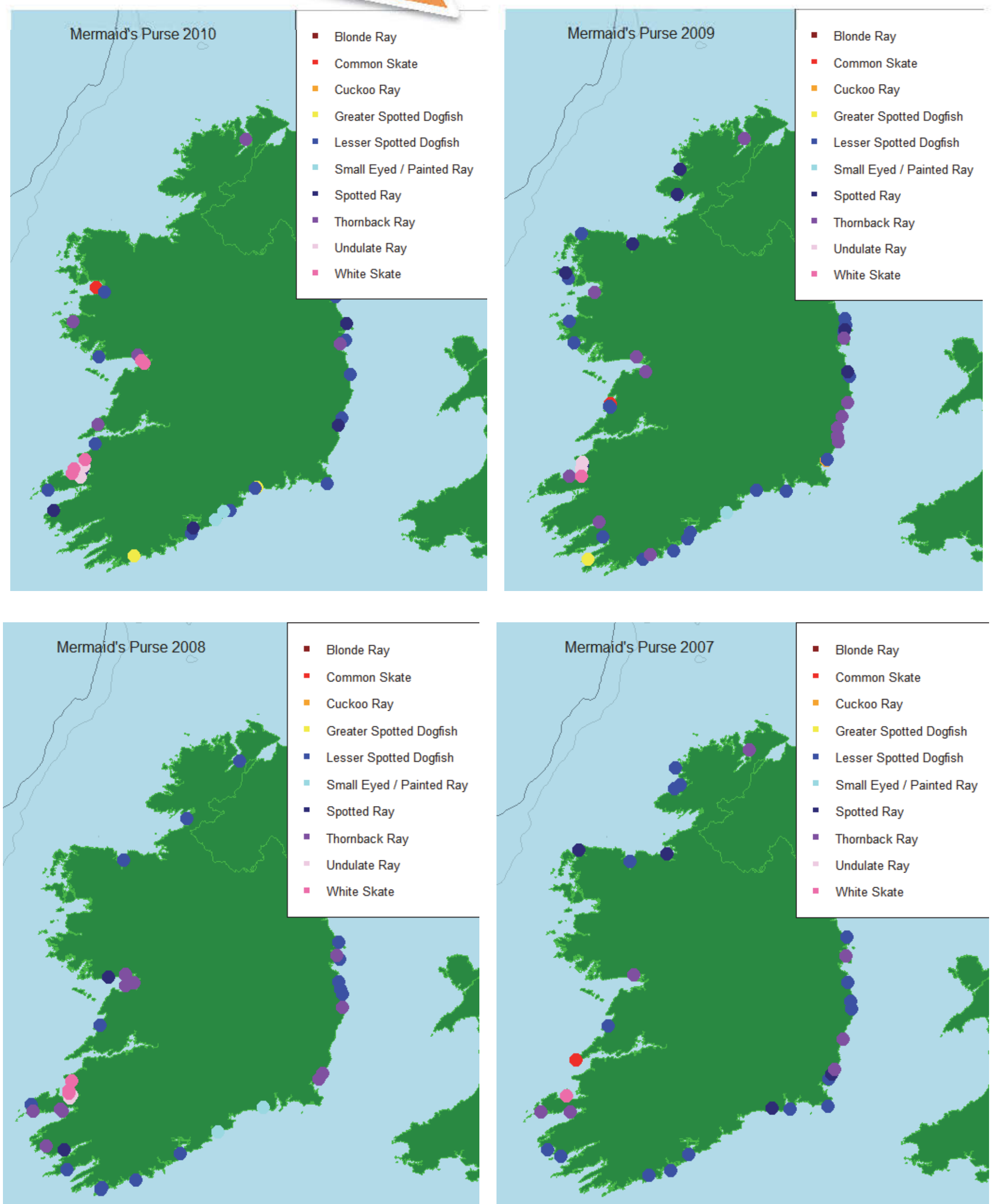


▲ Distribution of elasmobranches commonly caught in NWW based on catch rates from the 2013 data of the international bottom trawl survey (Data from ICES.dk).

Eggcase Distribution in Ireland

Citizen Science

Data on elasmobranch egg cases are collected by the public, who report any sightings of *mermaid's purses* to Purse Search Ireland at www.marinedimensions.ie



▲ Distribution of eggcases around Ireland's coastline for all species, as reported by volunteer observers. These purses are laid by the adult female fish in a suitable habitat on the seafloor, and are often washed up in seaweed along the upper shoreline. Observations of these purses on the seashore and underwater can help to determine the location of nursery areas. (Data courtesy of Sarah Varian at www.marinedimensions.ie.)

11

IMPORTANT FISH SPAWNING AREAS

Key Points

NWW contain important spawning areas for mackerel, horse mackerel and blue whiting. These species migrate into and out of the NWW area each year.

The NWW area is a very important spawning area for blue whiting, mackerel and horse mackerel. Each year these highly migratory species move into this area, spawn and move away from the western part of NWW.

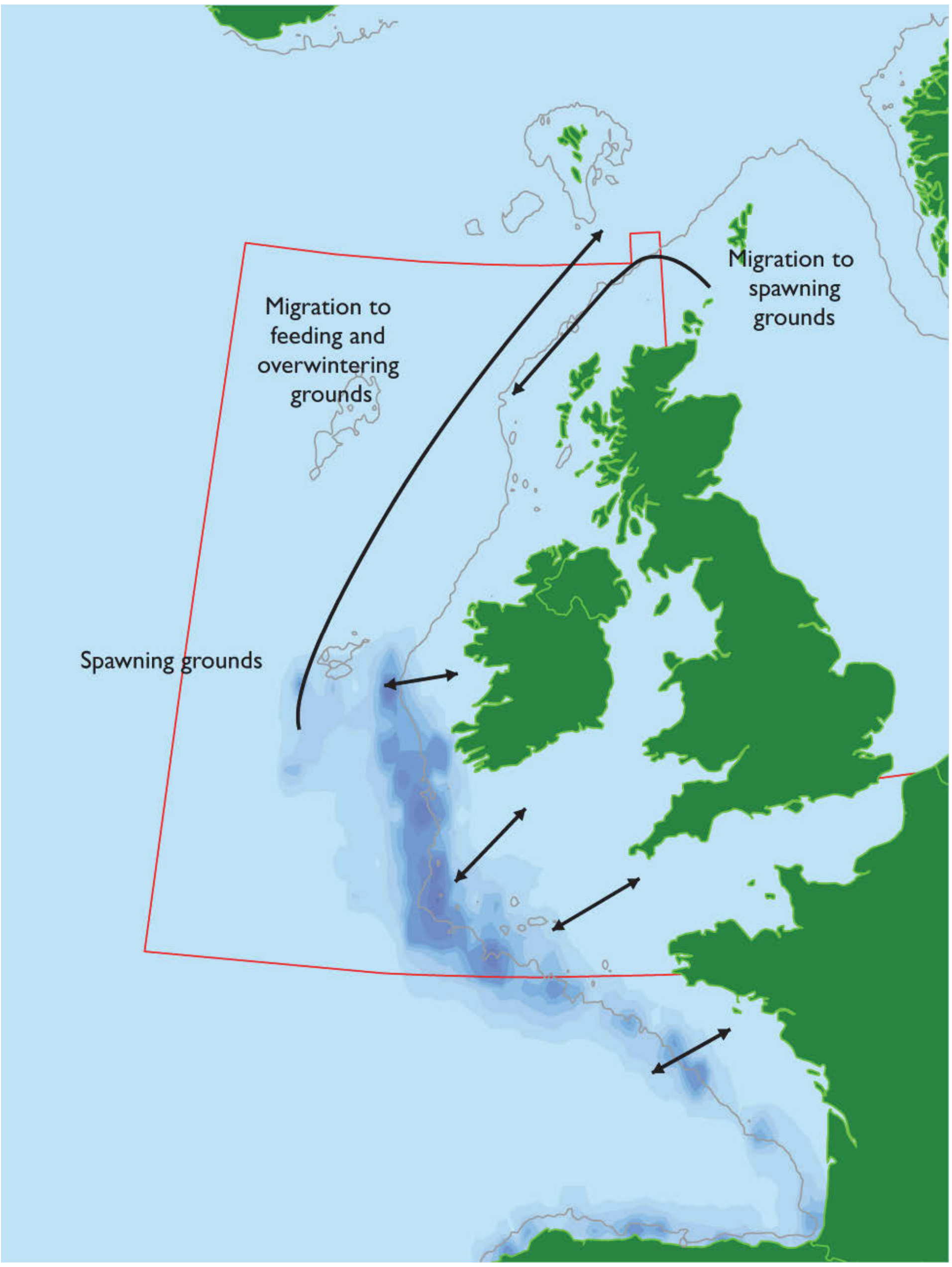
There are important whitefish spawning areas in NWW. Cod spawning takes place in the northern Irish Sea and in the Celtic Sea off the south eastern coast of Ireland and off Cornwall. There are hake, megrim and monkfish spawning areas off the south west of Ireland and along the slope to the west of Ireland and Scotland. Whiting, sole and plaice spawn in the Celtic Sea and in the Irish Sea.

Important herring spawning areas can be found in the Celtic Sea, North west of Ireland and along the west coast of Scotland. Herring spawn on gravel beds in inshore waters.

The NWW area is a very important spawning area for blue whiting, mackerel and horse mackerel. Each year these highly migratory species move into this area, spawn and move away from the western part of NWW. There are also important whitefish spawning areas in NWW. Cod spawning takes place in the northern Irish Sea and in the Celtic Sea off the south eastern coast of Ireland and off Cornwall. There are hake, megrim and monkfish spawning areas off the south west of Ireland and along the slope to the west of Ireland and Scotland. Whiting, sole and plaice spawn in the Celtic Sea and in the Irish Sea. Important herring spawning areas can be found in the Celtic Sea, North west of Ireland and along the west coast of Scotland.

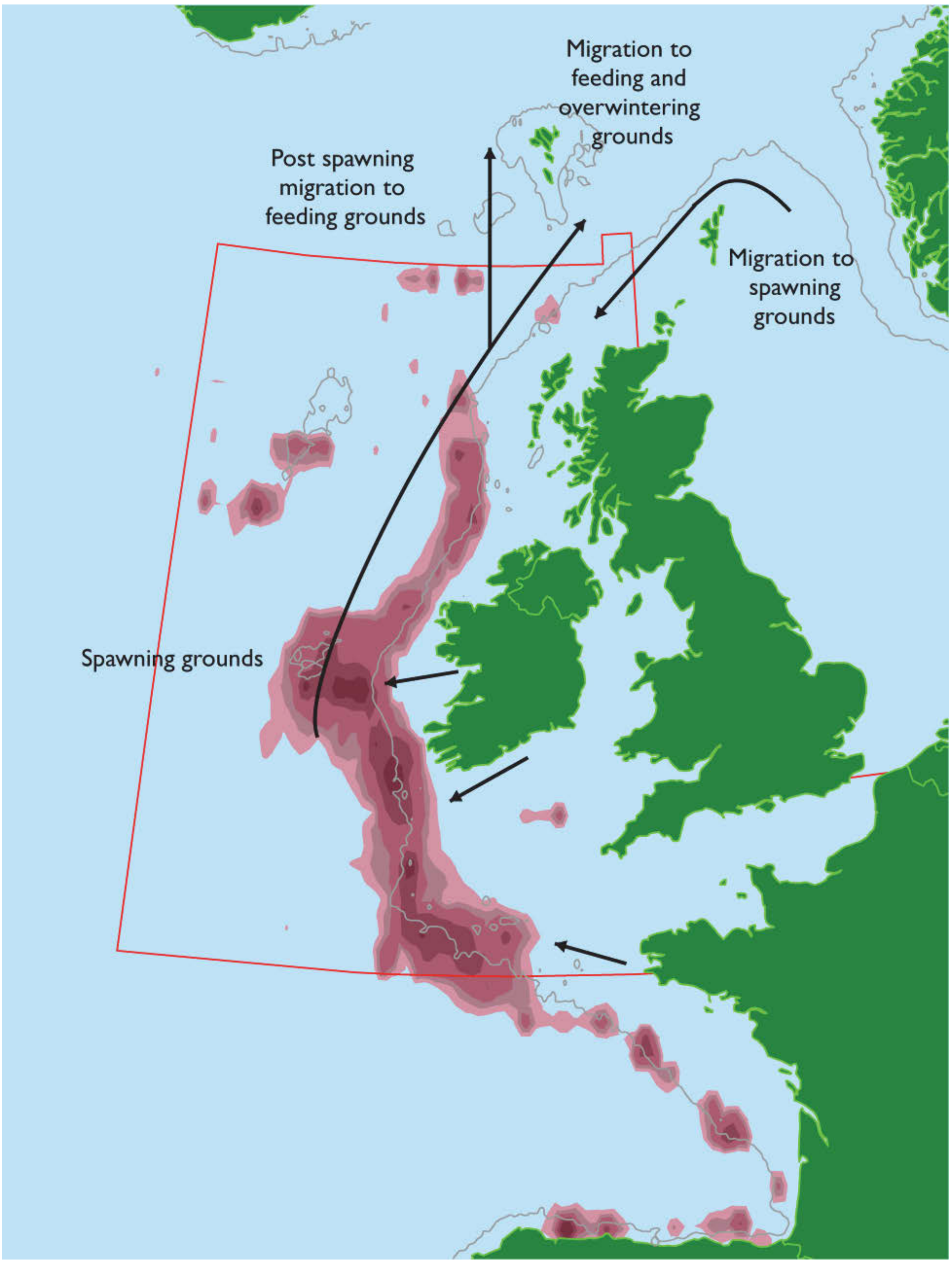
Horse Mackerel Migration

The figure below shows a schematic outline of assumed migration route (black arrows), spawning areas and overwintering areas for the western horse mackerel stock in the north east Atlantic. Shaded blue are mean egg production values between 2001 and 2010 ▼.



Spawning and Migration of Mackerel

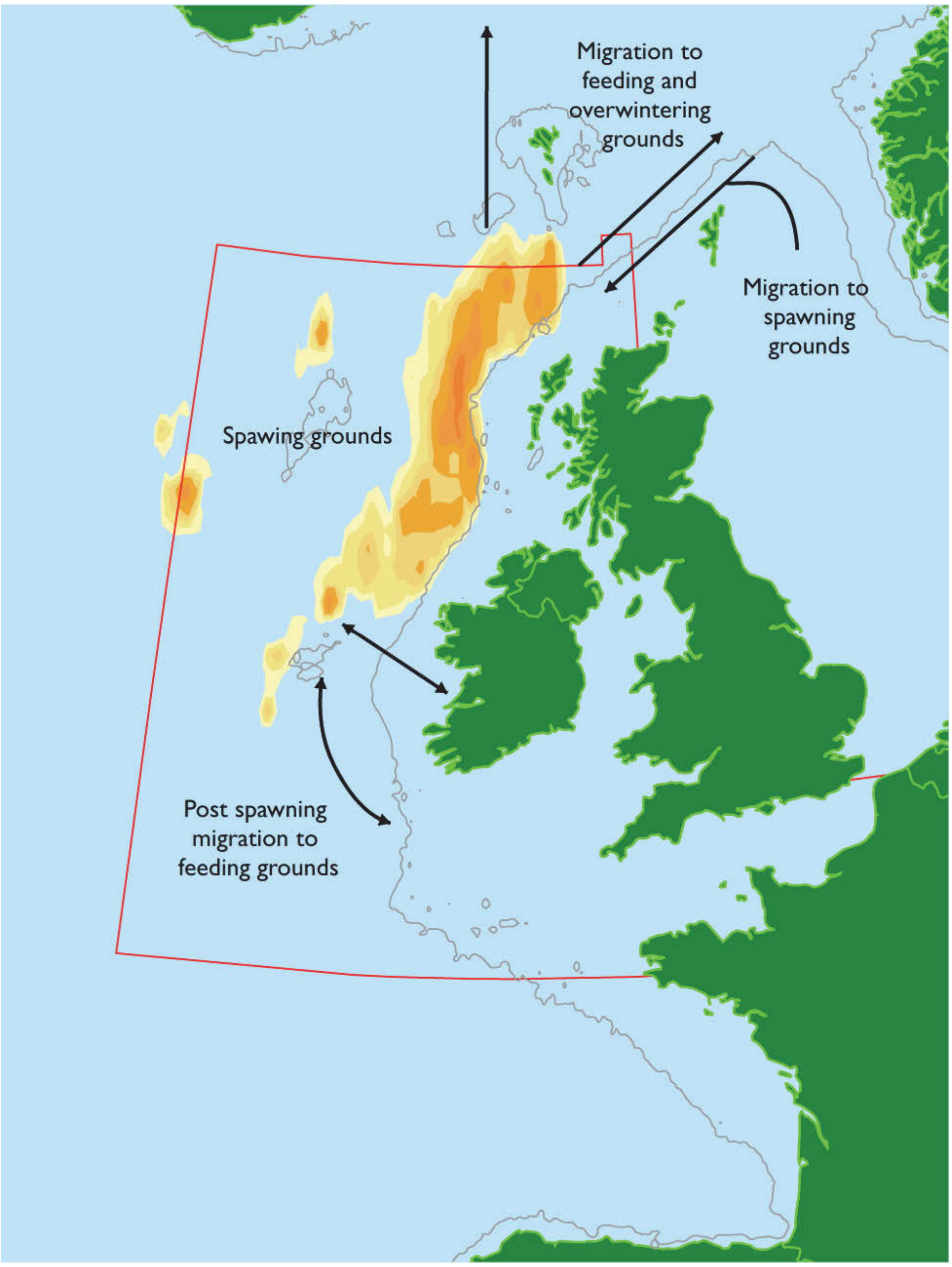
The figure below shows a schematic outline of assumed migration route (black arrows), spawning areas and overwintering areas for NEA mackerel stock in the north east Atlantic. Shaded purple are mean egg production values between 2001 and 2010 ▼.



Mackerel spawning starts in February to March, expands northwards through April, May and June and ends off the south west of Ireland in July.

Spawning and migration of Blue Whiting

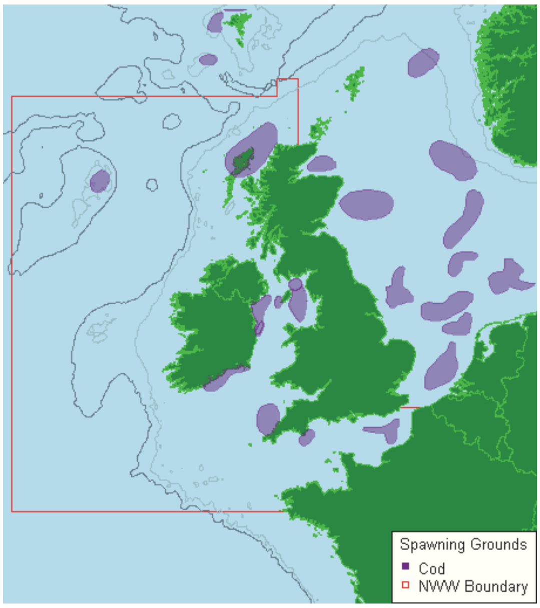
The figure below shows the spawning area of Blue Whiting in orange, and the migration pattern, shown by arrows. Spawning area is derived from the mean NASC values* 2006-2010. The position and strength of the North Atlantic sub-polar gyre appears to influence the spawning success of blue whiting by constraining spawning along the European continental slope and south of Porcupine Bank (Hatun et al. 2009) ▼.

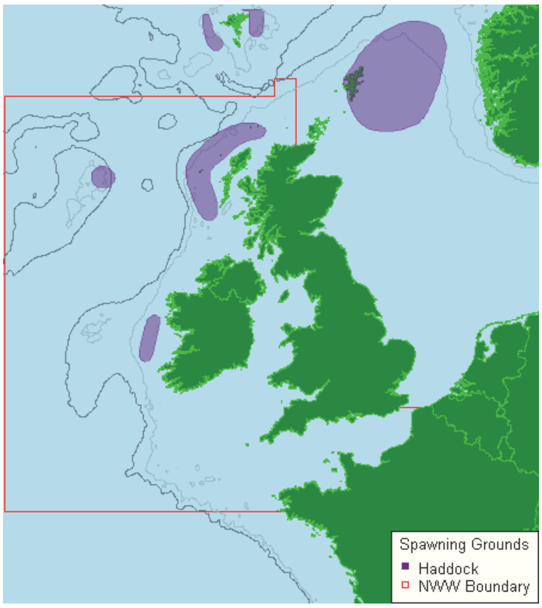


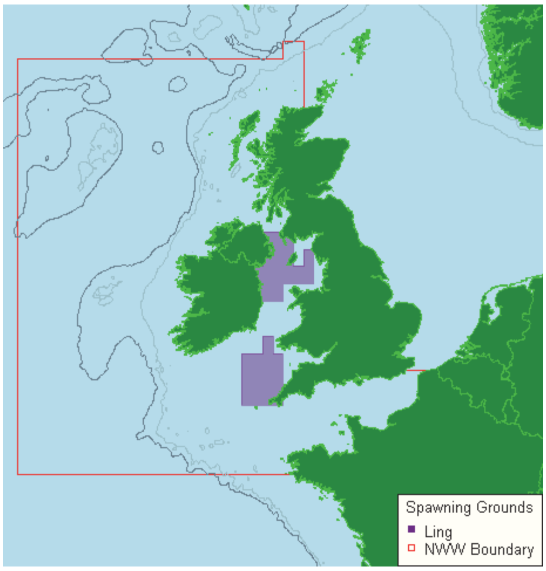
* NASC: Nautical area scattering coefficient derived from blue whiting acoustic surveys.

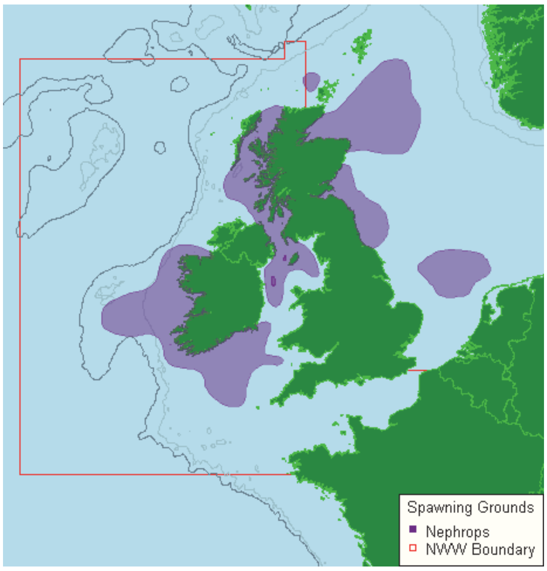
Important Spawning and Nursery Grounds

The following pages show maps of important spawning grounds for commercially caught species of fish in and around the NWW.

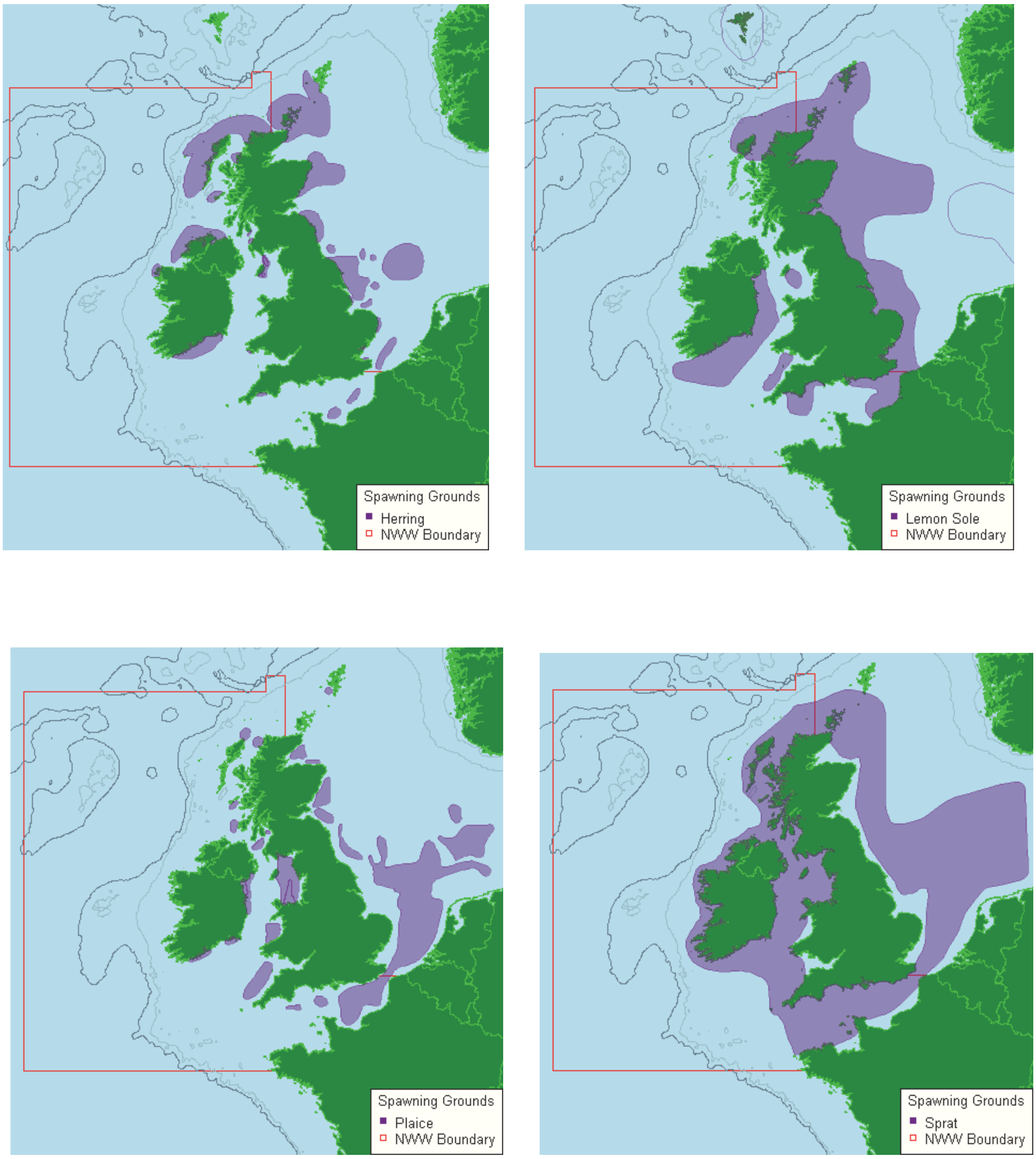




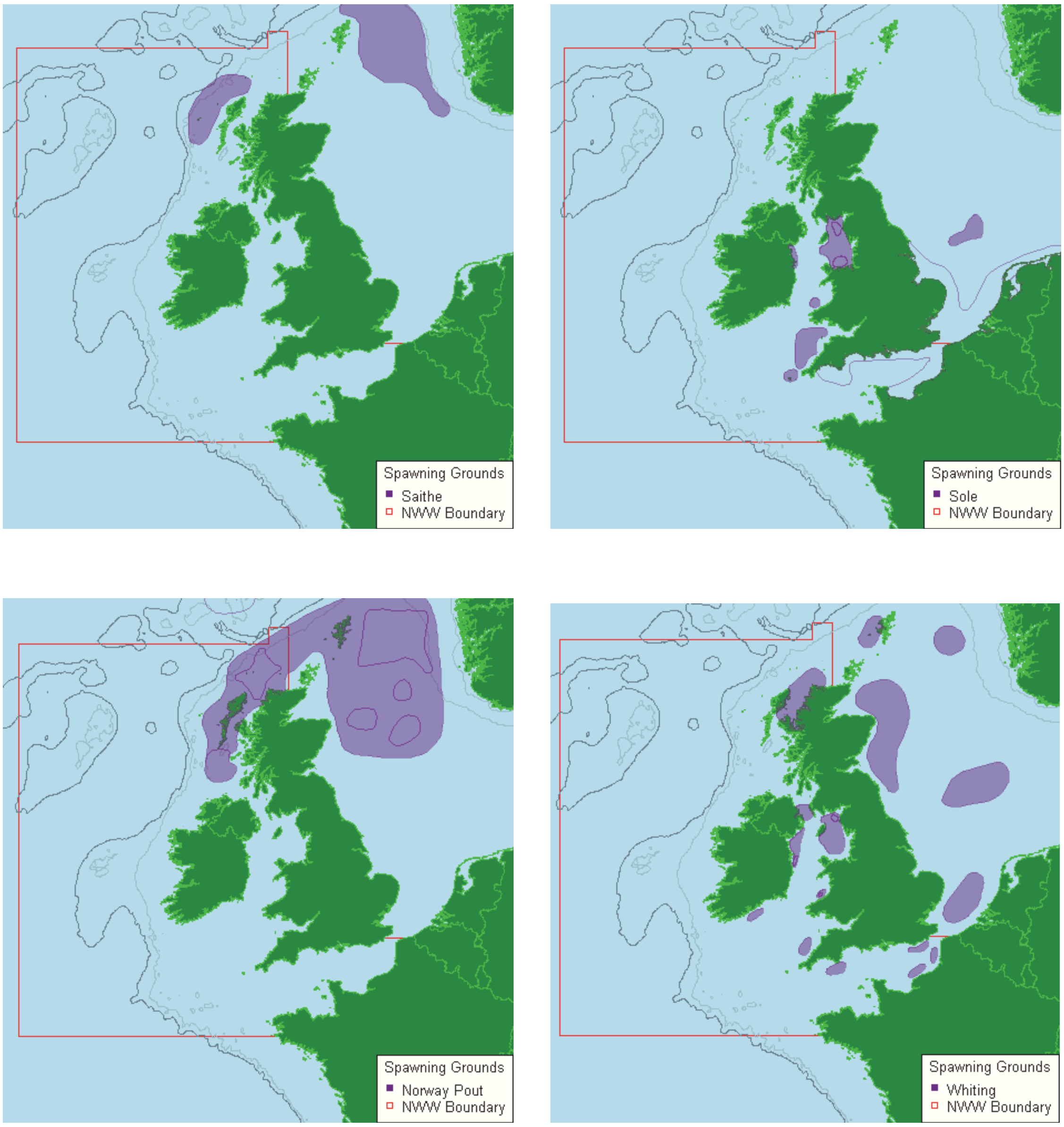




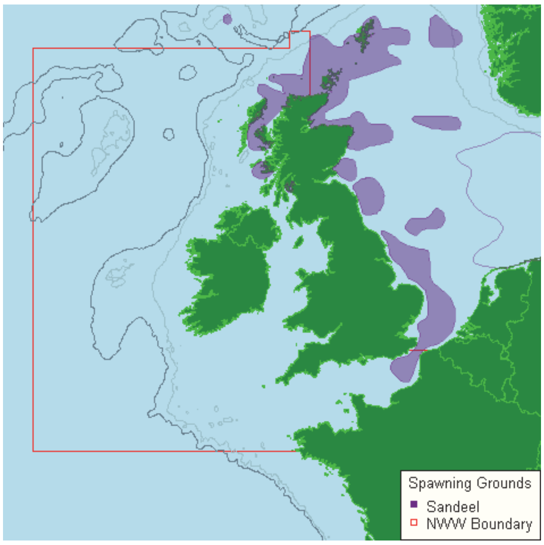
▲
Spawning grounds for Cod (upper left), Haddock (upper right), Ling (lower left) and *Nephrops* (lower right), in and around the NWW
(GIS Source: CEFAS 2010).

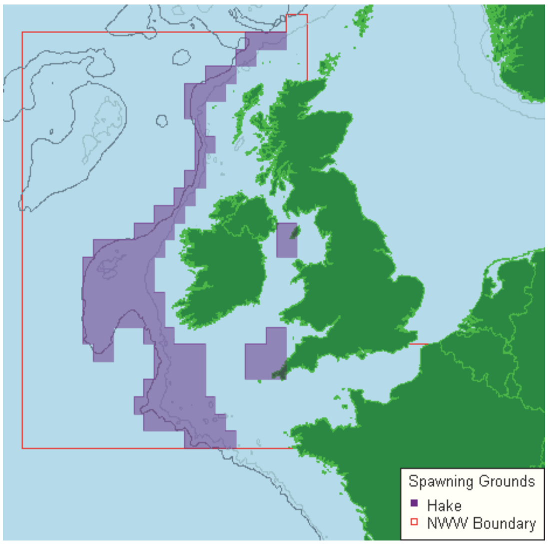


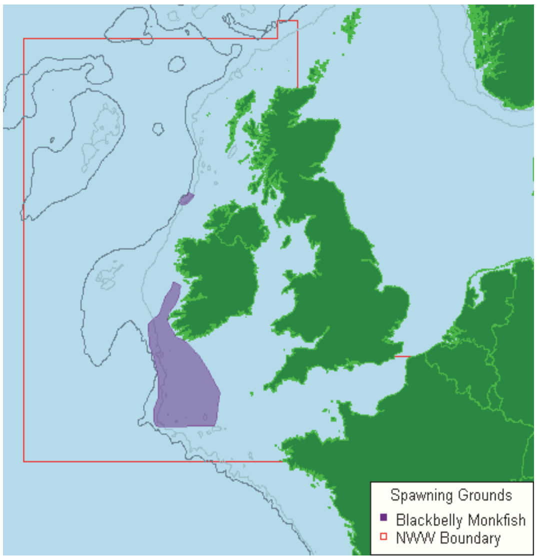
▲
Spawning grounds for Herring (upper left), Lemon Sole (upper right), Plaice (lower left) and Sprat (lower right), in and around the NWW
(GIS Source: CEFAS 2010).

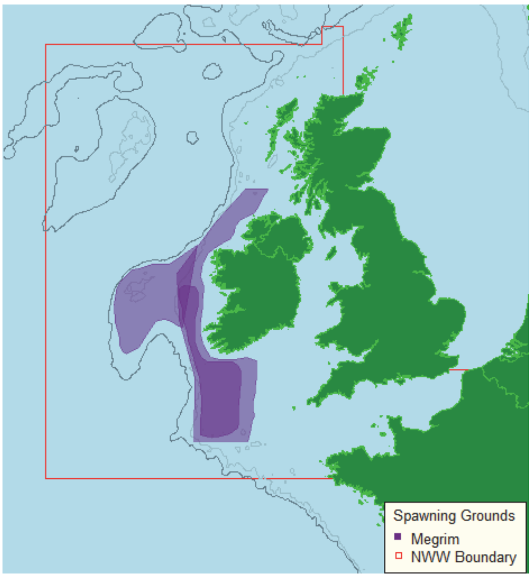


▲
Spawning grounds for Saithe (upper left), Sole (upper right), Norway Pout (lower left) and Whiting (lower right), in and around the NWW
(GIS Source: CEFAS 2010).









▲
Spawning grounds for Sandeel (upper left), Hake (upper right), Blackbelly Monkfish (lower left) and Megrim (lower right), in and around the NWW
(GIS Source: CEFAS 2010).

12

DISTRIBUTION OF JUVENILE FISH

Key Points

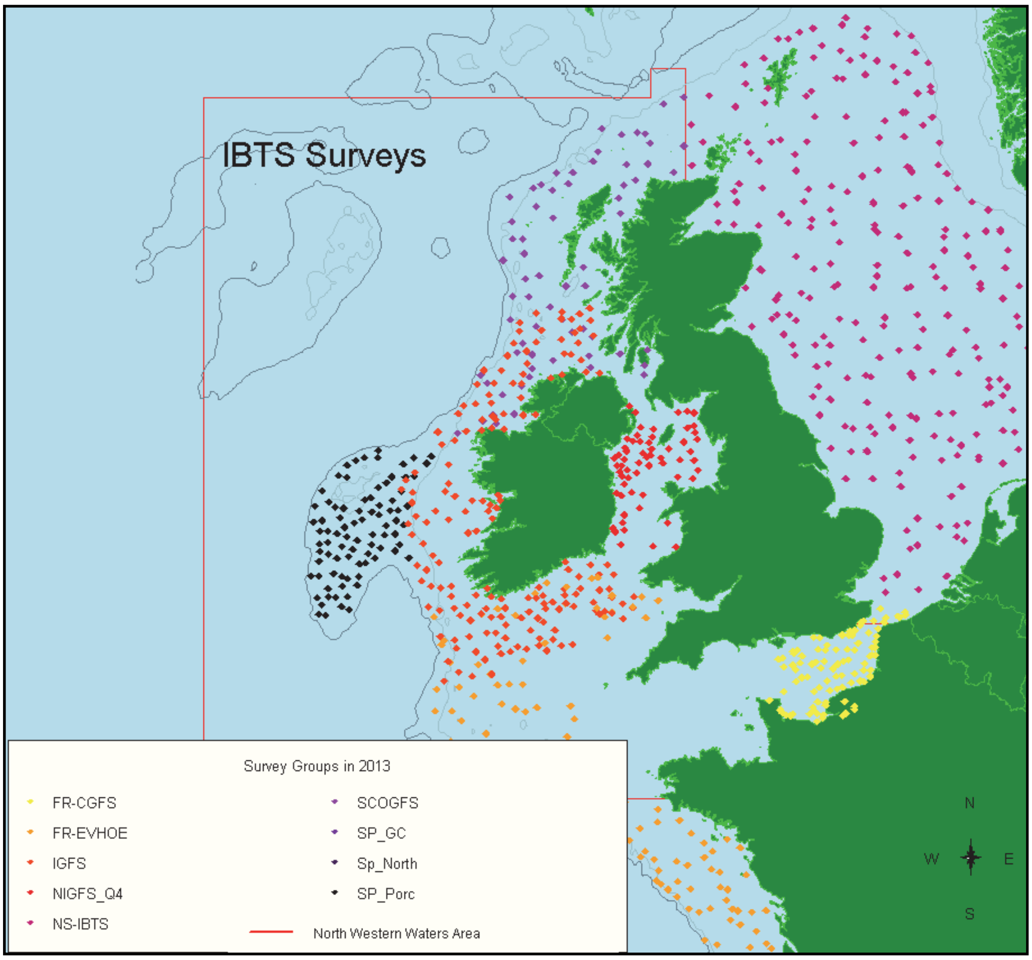
Research surveys use a small mesh to capture juvenile fish. These provide information so that the distribution of juvenile fish can be mapped in order to identify important nursery areas.

ICES co-ordinates 12 annual ground fish surveys in the NWW, which are carried out by the UK (Scotland, Northern Ireland, England and Wales), France, Spain and Ireland.

These surveys assess the distribution and abundance of fish species (adult and juveniles) for stock assessment and ecological studies.

Distribution of juvenile and adult fish in the NWW is presented, based on a total of 581 valid hauls made during the 2013 ground fish surveys.

In the NWW, ground fish surveys are carried out and co-ordinated by ICES to assess the distribution and abundance of fish species (adult and juveniles) for stock assessment and ecological studies. The surveys are co-ordinated through the ICES International Bottom Trawl Survey Working Group (IBTS). In the NWW area, ground fish surveys are conducted by the UK (Scotland, Northern Ireland, England and Wales), France, Spain and Ireland.



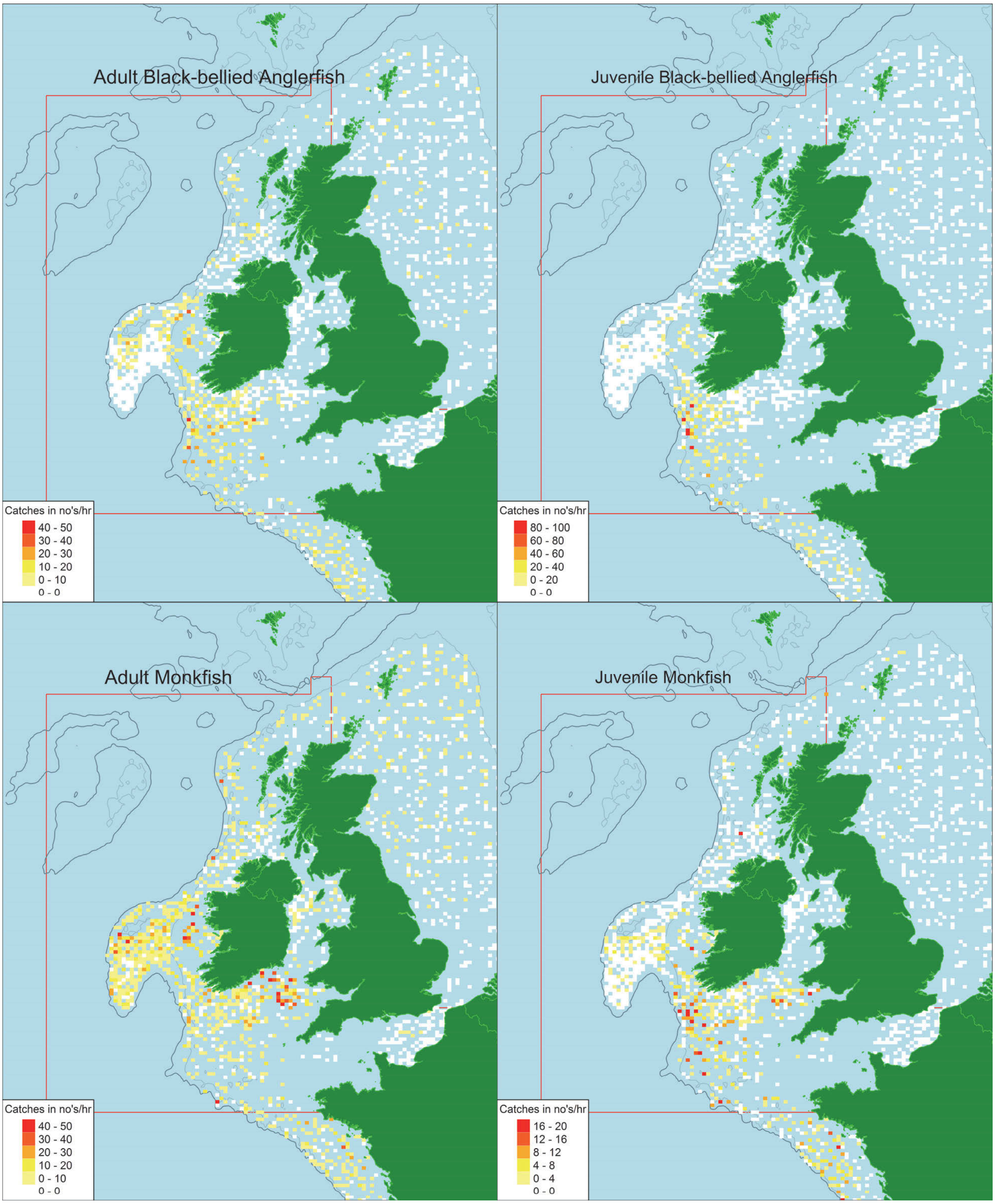
▲ Station positions of the various ground fish surveys carried out in North East Atlantic and North Sea in 2013 (Source: ICES IBTS, 2014).

Information from Ground fish Surveys

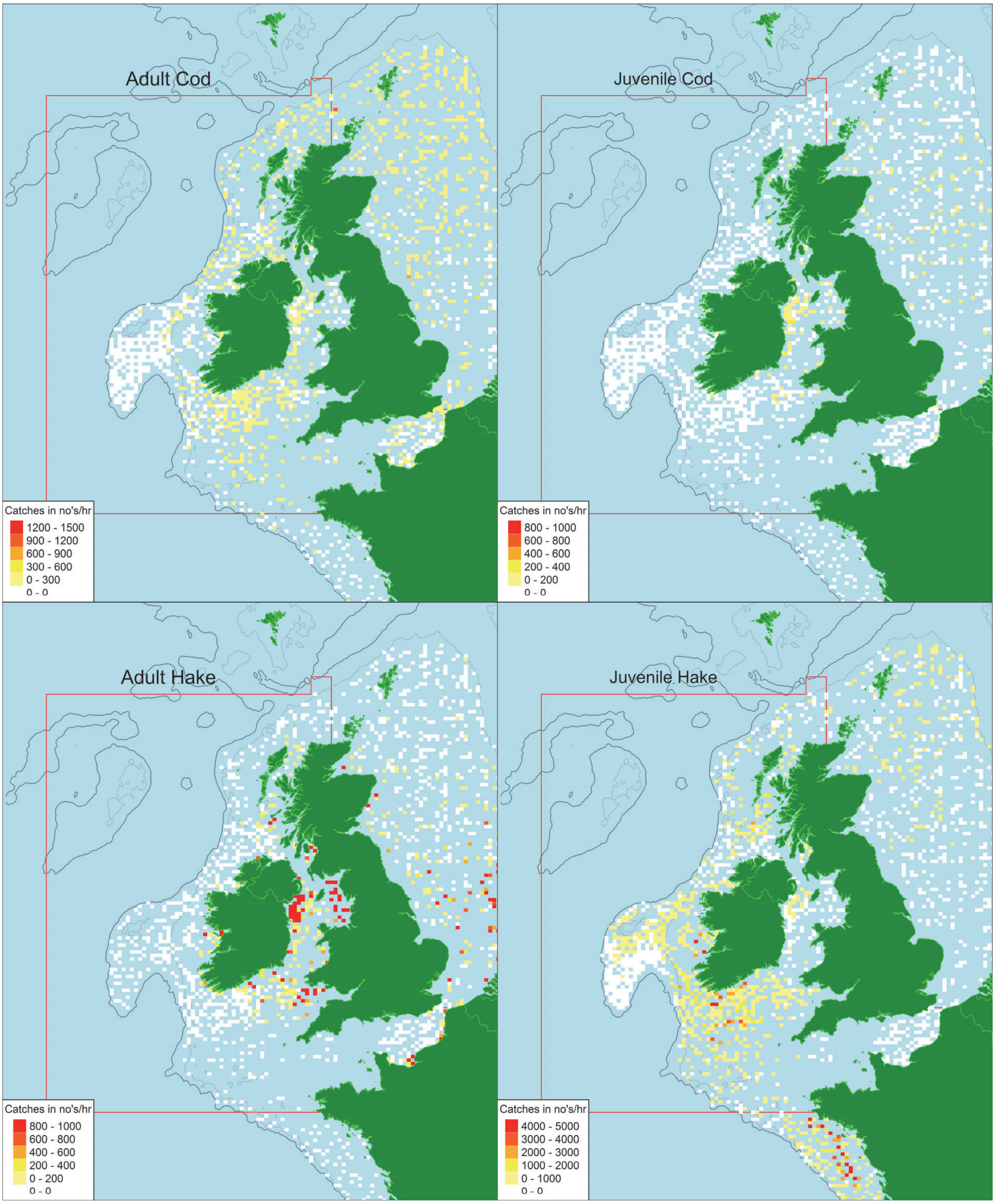
The following maps show the distribution of juvenile and adult fish in the NWW by combining the IBTS survey data from the North Sea and Western Atlantic areas (St. Georges Channel, Irish Sea and Western Atlantic). In examining the following maps of species distribution, two aspects need to be borne in mind: (1) The North Sea (NS) survey relates to Quarter 3 while the Western Area (WA) relates to Quarter 4. (2) There are a number of different trawl types used in the WA, whereas a single trawl gear is used in the NS.

The maps give catch numbers per hour for juvenile and adult fish for a selected number of species. Juvenile fish have spawned in the current year of the survey (i.e. fish less than 1 year old – 0 group fish).

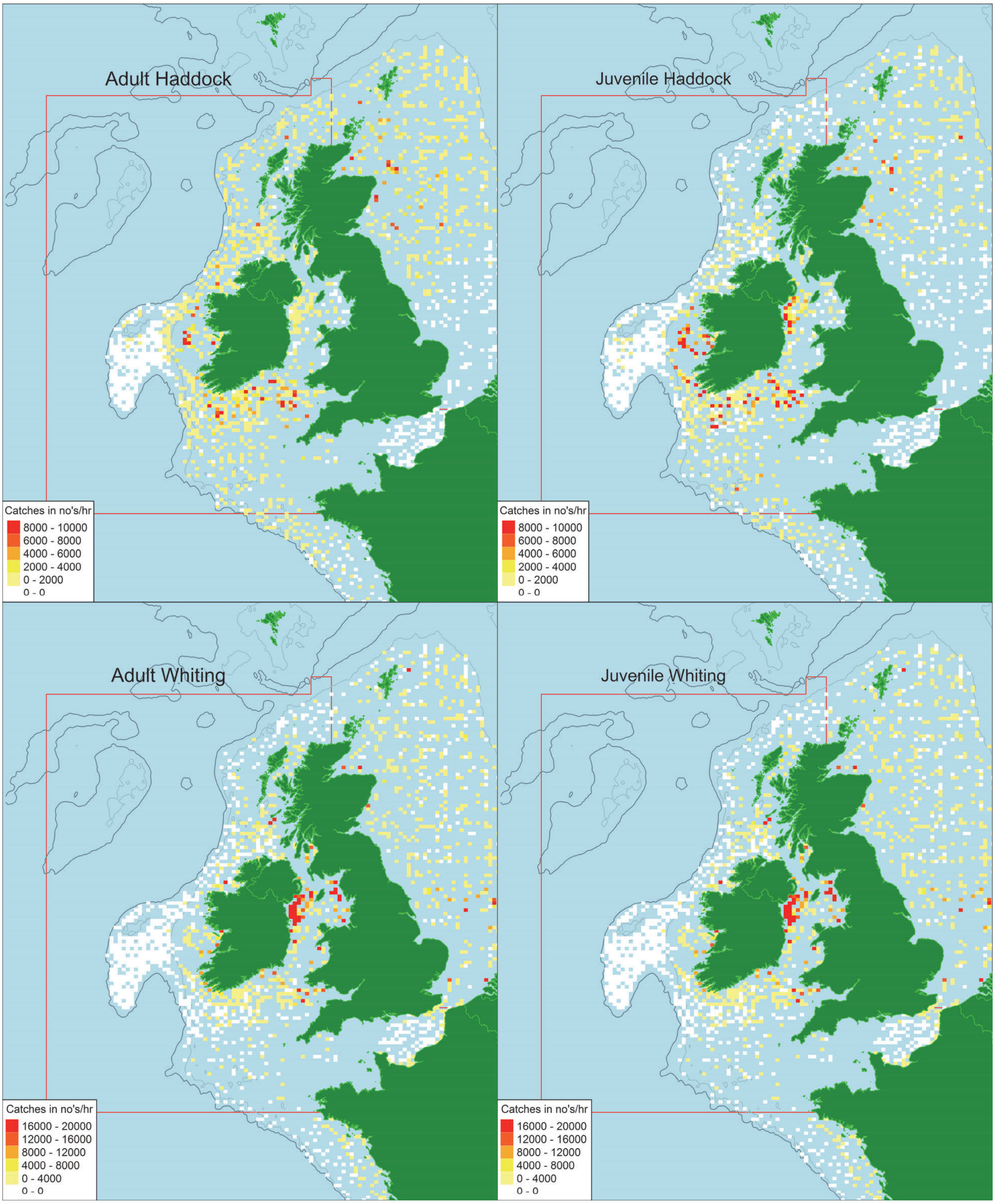
(See: http://www.ices.dk/marine-data/data-portals/Pages/DATRAS.aspx)



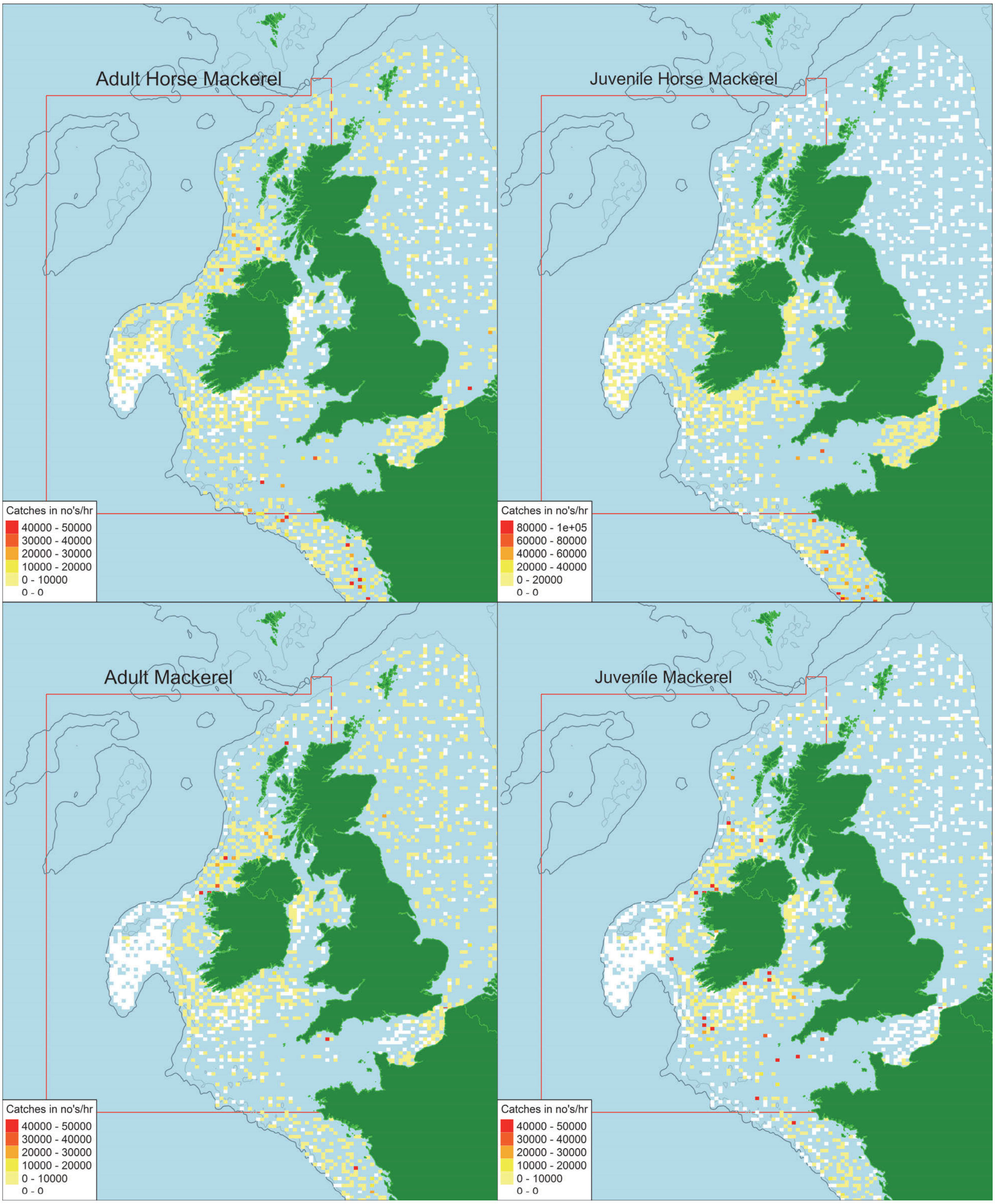
▲ Catches in numbers per hour of 1+ and 0 group black bellied anglerfish (upper panel) and monkfish (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014)



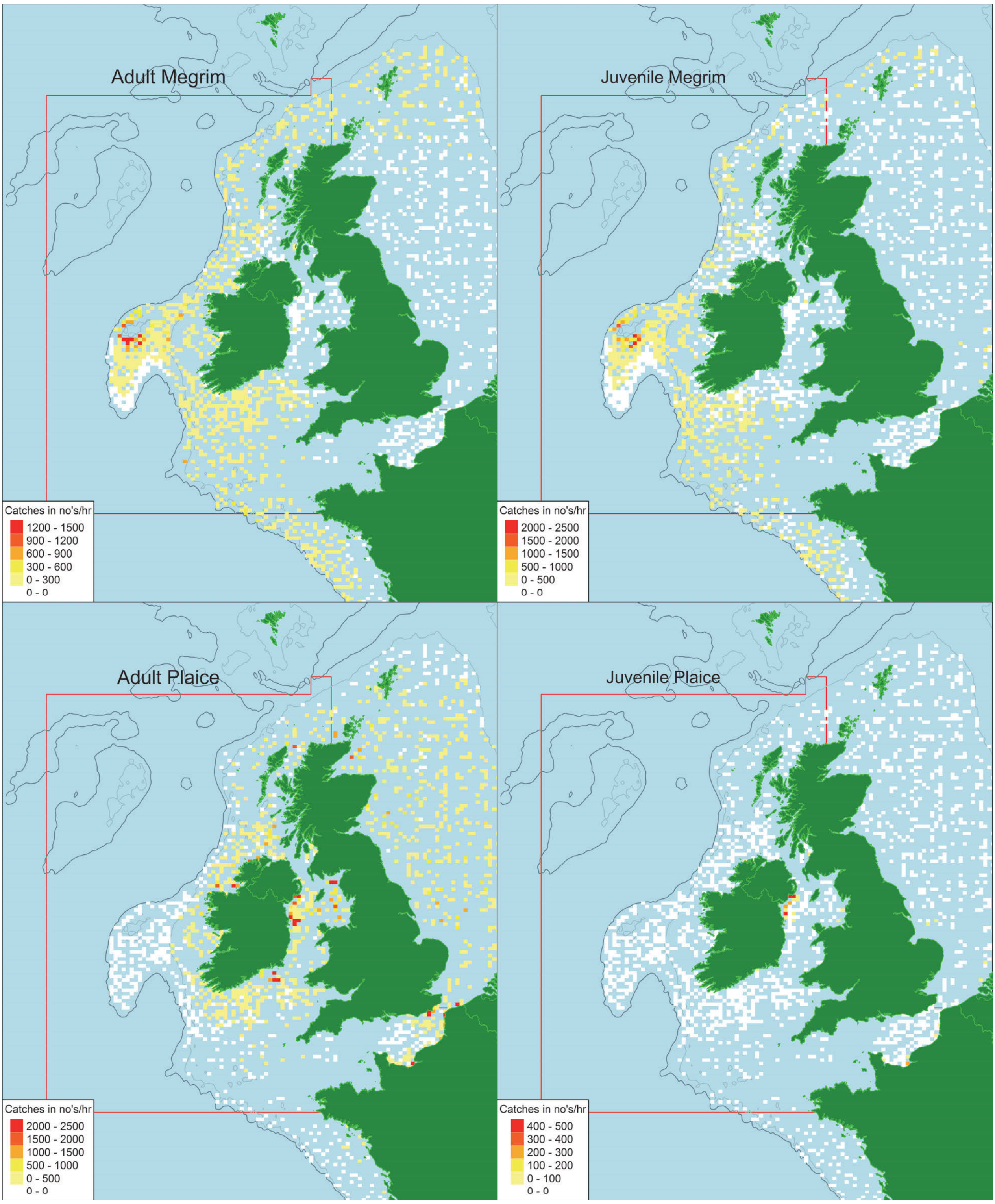
▲ Catches in numbers per hour of 1+ and 0 group cod (upper panel), and hake (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014).



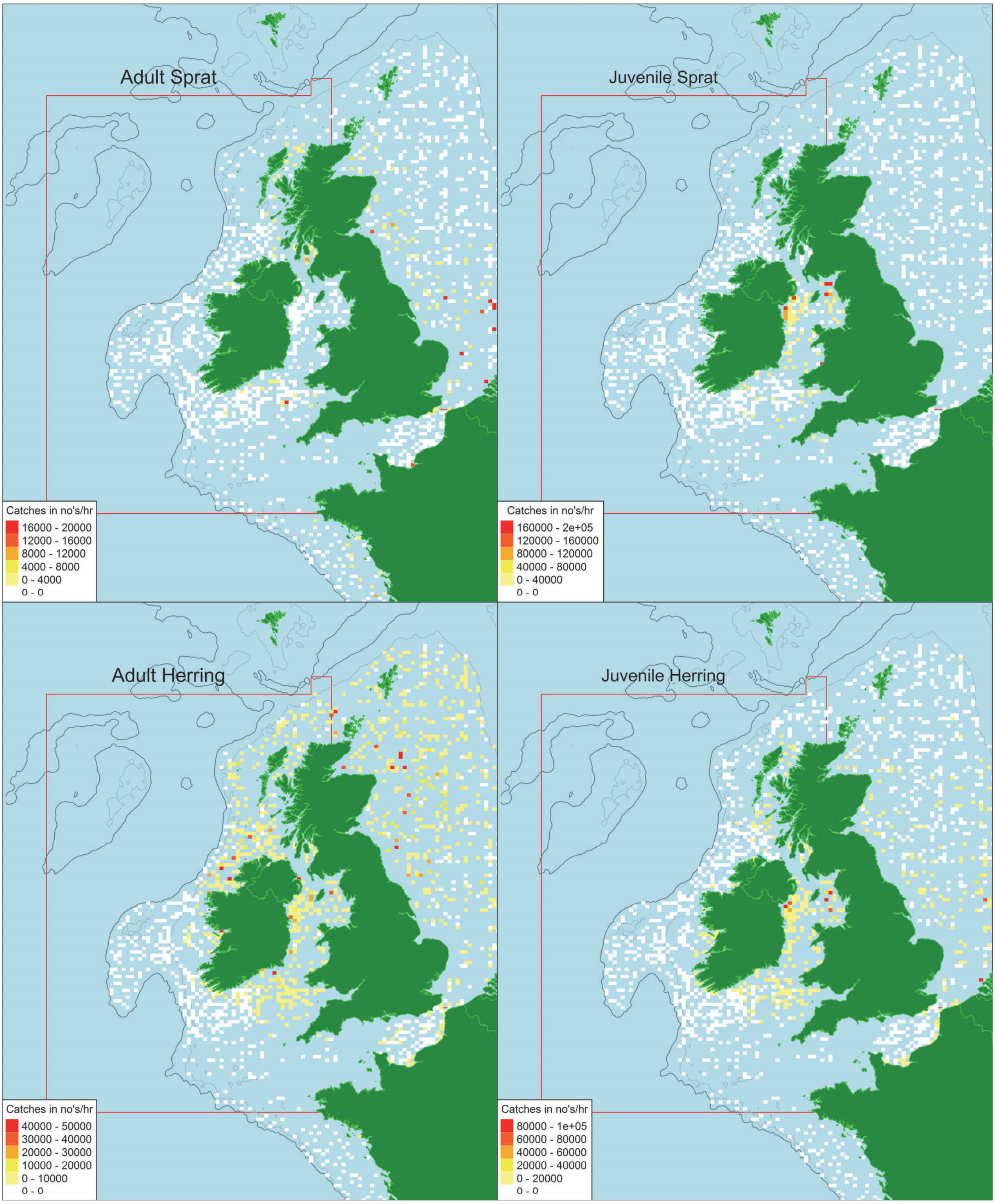
▲ Catches in numbers per hour of 1+ and 0 group haddock (upper panel), and whiting (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014).



▲ Catches in numbers per hour of 1+ and 0 group horse mackerel (upper panel) and mackerel (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014).



▲ Catches in numbers per hour of 1+ and 0 group megrim (upper panel), and plaice (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014).



▲ Catches in numbers per hour of 1+ and 0 group sprat (upper panel), and herring (lower panel) from the 2013 ground fish surveys (Source: ICES IBTS, 2014).

FISHING ACTIVITY

KEY POINTS

Total landings of wild capture fisheries from the NWW area (i.e. ICES Sub Areas VI and VII) for 2013 were around 1.3 million tonnes.

In Sub Area VI (North of Ireland and West of Scotland), the main pelagic species caught are mackerel and blue whiting. The main demersal species taken are hake, saithe, ling, monkfish and haddock. Important shellfish species taken in VI include *Nephrops*, crab and scallops.

In Sub Area VII (South and West of Ireland including the Irish Sea), the main pelagic species taken are horse mackerel, mackerel and herring. The main demersal species taken are monkfish, hake, whiting, haddock and megrim. Important shellfish species taken in VII include scallops, whelk, crabs and *Nephrops*.

Distribution of fishing grounds

▲ The main fishing grounds around Ireland. The names of the grounds are based on records from fisheries observers and the outlines of the area derived from VMS data (from Gerritsen and Lordan, 2014).

Fishers distinguish fishing grounds based on the bottom type and on the expected catch composition. Patterns emerge when observer records of fishing grounds are overlaid over fishing effort data from Vessel Monitoring Systems (VMS) and catch composition data from the logbooks as shown in the map above.

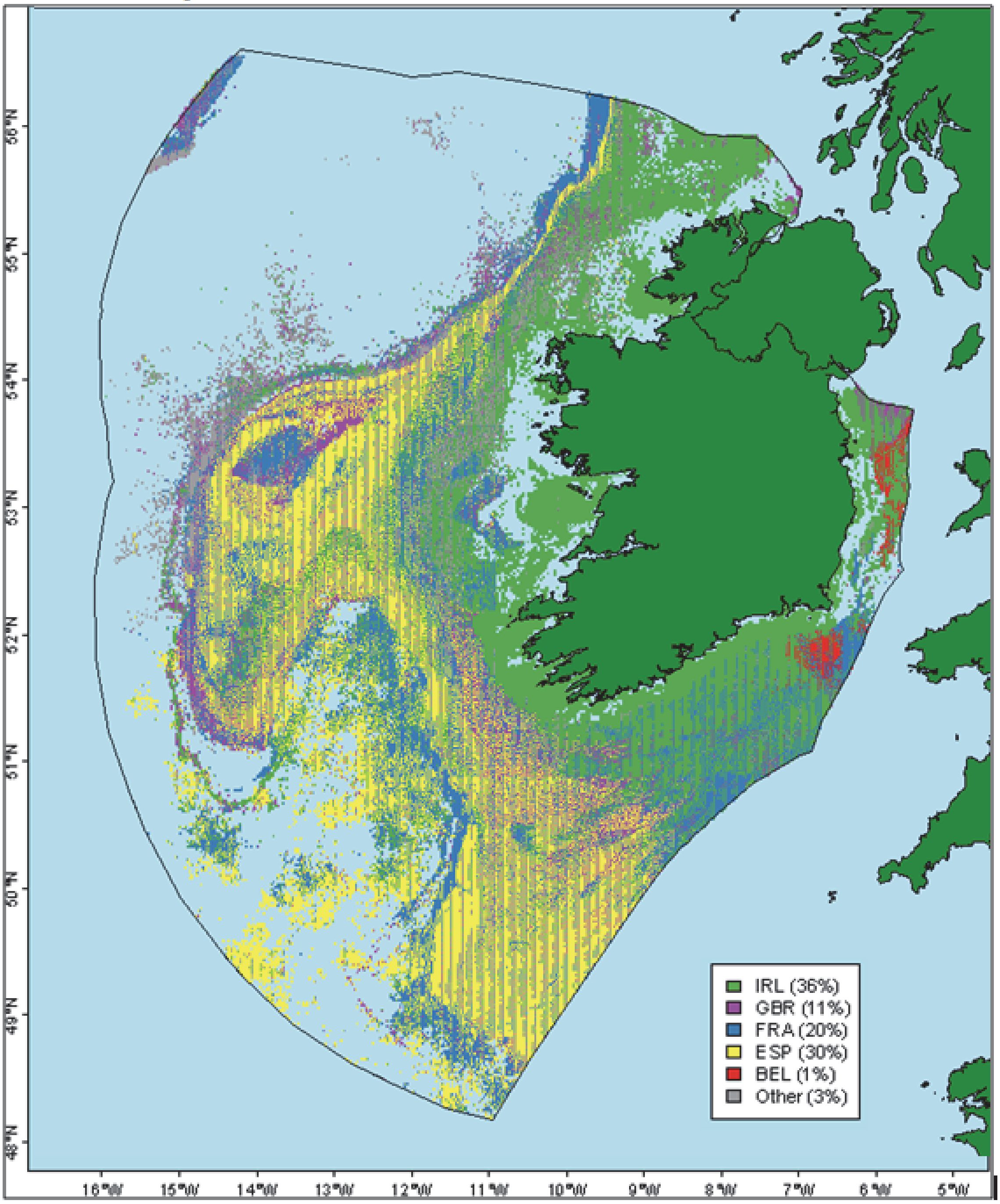
International wild capture fisheries landings in NWW

Official landings data have been reported to ICES for all species, areas, years and countries in the North-eastern Atlantic since 1985. The official data may vary somewhat from the best estimates used in ICES assessment working groups where more accurate data is sometimes provided by national scientists. Nevertheless the data can be used as a best estimate of landings of all species from each area. Total landings from the NWW area for 2013 were estimated to be about 1.3 million tonnes (ICES Catch Statistics from FAO FishStat Plus).

▼ Landings by country from Sub Areas VI and VII in 2013, by species category (weights in tonnes) (Source: FAO FishStat).

	Pelagic and Industrial	Shellfish	Demersal	Elasmobranchs	Deepwater	Grand Total
ICES VI total	**359547**	**32399**	**33874**	**1115**	**8467**	**435402**
Germany	30885	91	136	0	417	**31529**
Denmark	3360	0	0	0	125	**3485**
Spain	6	0	801	61	997	**1865**
Faeroe Isle	15795	0	321	68	10	**16194**
France	5813	42	9928	416	4432	**20631**
Ireland	61737	3139	2720	208	6	**67810**
Iceland	10989		0	0	0	**10989**
Netherlands	47638	0	90	0	1430	**49158**
Norway	49346	0	4132	126	430	**54034**
Russia	25008		5	0	0	**25013**
UK	108970	29127	15741	236	620	**154694**
ICES VII total	**506787**	**188795**	**171757**	**17524**	**1983**	**886846**
Belgium	87	1450	8897	1565	0	**11999**
Germany	36739	35	338	0	0	**37112**
Denmark	19581	0	9	0	0	**19590**
Spain	3111	3100	24192	351	1158	**31912**
France	39224	82066	81374	11305	703	**214672**
Gurnsey	42	1086	151	130		**1409**
Ireland	108383	23124	25269	1214	24	**158014**
Isle of Man	21	6193	10	5		**6229**
Jersey	8	1169	39	83		**1299**
Lithuania	0		0		0	**0**
Netherlands	102668	360	2633	45	9	**105715**
Norway	137742	0	0	0	0	**137742**
Russia	14757					**14757**
UK	44424	70212	28845	2826	89	**146396**
NWW total:	**866334**	**221194**	**205631**	**18639**	**10450**	**1322248**

Vessel nationality



▲ The nationality of vessels ≥15m fishing in the Irish EEZ (all gears combined). IRL = Ireland; GBR = United Kingdom; FRA = France; ESP = Spain; BEL = Belgium. The percentages in the legend refer to the share of the total effort inside the EEZ for each country (adapted from Gerritsen and Lordan, 2014).

VMS data within the Irish EEZ indicates that most of the fishing effort is carried out by foreign vessels; Ireland is responsible for 36% of the international effort of vessels ≥15m and consists of mainly demersal otter trawlers. Spain accounts for 30% of the effort (mainly demersal otter trawlers and longliners) and France and the UK account for 20% and 11% of the effort (dominated by demersal otter trawlers for both countries). The mapping of fine scale fishing effort requires the availability of VMS and logbook data from all fishing nations in the NWW.

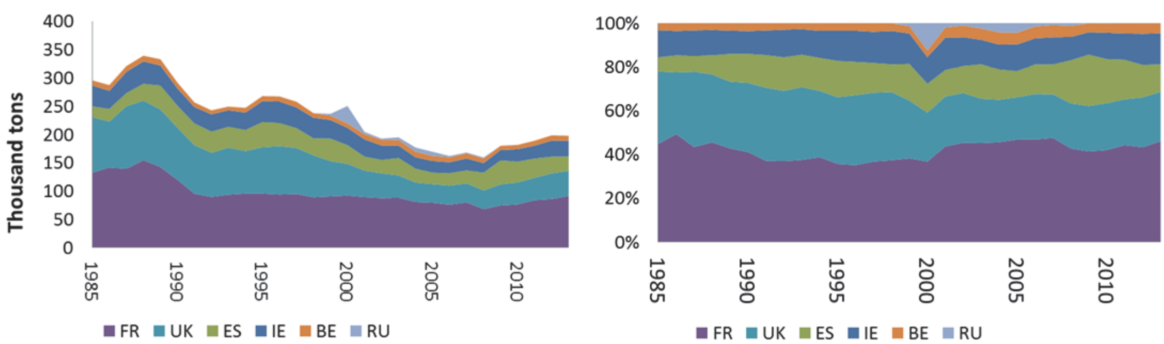
Landings by nation and species in NWW in 2013

The top demersal species landed in 2013 in NWW are shown below by fishing nation.

	Hake	Haddock	Monkfishes	Whiting	Saithe	Megrim	Ling	Cod	Sole
ICES VI total	6054	5517	4789	217	8534	1231	4632	185	20
Ger	0	0	136	0	0	0	0	0	0
Spain	110	14	123	0	21	213	86	0	
Faeroe I	0	0	0	0	25		50	0	
France	3196	51	1777	1	3814	106	736	3	0
Ireland	196	852	572	97	313	384	62	15	18
Netherl	89	0	0	0	0	0	0	0	0
Norway	41	127	10	0	715		1960	27	
UK	2422	4473	2171	119	3646	528	1738	140	2
ICES VII total	**20108**	**14549**	**24154**	**15649**	**984**	**9408**	**2705**	**6940**	**6685**
Belgium	12	181	1124	323	2	521	52	267	1871
Ger	0	0	320	0	0	0	3	0	0
Spain	13333	8758	14957	7082	263	3692	1222	4927	3332
France	1	21	3	738	0	0	0	39	0
Ireland	2958	1613	6229	1399	232	3067	644	755	1401
Netherl	12	181	1124	323	2	521	52	267	1871
UK	0	0	320	0	0	0	3	0	0
NWW total: 156024	**37475**	**19284**	**33462**	**16696**	**10392**	**16105**	**8003**	**7785**	**6822**

Trends in demersal landings by fishing nation over time

Trends in international landings of demersal species between 1985 and 2013, both as total weight and percentage, by fishing nation are shown below. These data show a general decline in the landings of demersal species since the late eighties until 2006. Small increases in landings have occurred since then. National proportions are relative stable over time with France and UK landing the largest share, followed by Spain and Ireland.



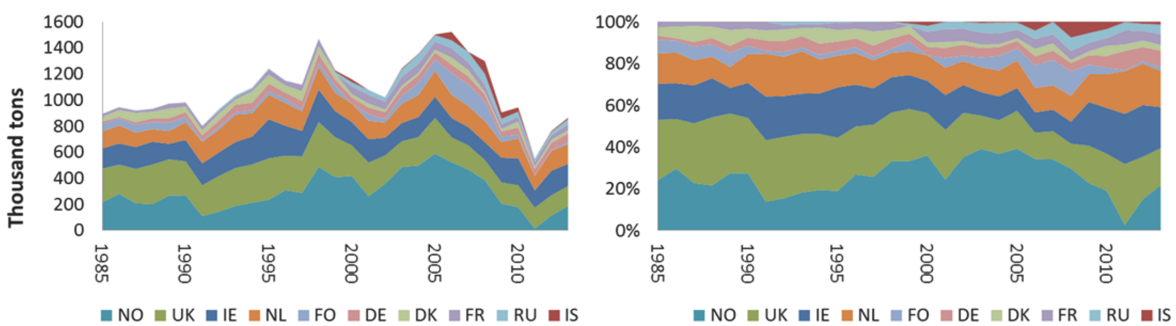
▲ International landings of demersal species in NWW, country codes are FR= France; ES= Spain; IE= Ireland; UK= United Kingdom; BE= Belgium and RU= Russia (ICES Catch Statistics from FAO FishStat Plus).

Pelagic and industrial species: The top 10 pelagic and industrial species for 2013 are shown below.

	Mackerel	Blue whiting	Herring	Jack and horse mackerels	Horse mackerel	Boarfish	Sprat	Sardine	Albacore	Ar gen tine
ICES VI total	**133391**	**149258**	**27177**	**32141**	**12032**	**553**	**1455**	**0**	**0**	**3210**
Germany	9196	8744	4024	8616	0		0	0		0
Denmark	875	1844	208		433	0	0	0		
Faeroe	17	12581	0		0		0			3197
France	1872	2906	445	590	0		0	0	0	
Ireland	30844	5315	4574	19774	205	538	487	0	0	0
Iceland	0	10989	0							
Netherl	7558	26515	2171		11394		0	0		0
Norway	734	48607	0		0	0	0			0
Russia	0	24995			0					13
UK	82295	6762	15755	3161	0	15	968	0	0	0
ICES VII total	**41064**	**198674**	**62662**	**43877**	**58507**	**66765**	**8764**	**16128**	**6684**	**1**
Germany	5155	2597	10277	18491	0		0	214		0
Denmark	28	46	249		7390	11828	0	40		
Spain	0	225	0		0		0			
France	6749	4266	9427	1923	1467	0	2	10112	4790	0
Ireland	12236	7891	14804	15659	147	50572	4967	236	1818	1
Netherl	7897	24413	19051		49503		0	1804		0
Norway	0	137742	0		0		0			0
Russia		14757								
UK	8999	6737	8854	7804	0	4365	3795	3722	76	0
NWW total 862343	**174455**	**347932**	**89839**	**76018**	**70539**	**67318**	**10219**	**16128**	**6684**	**3211**

Pelagic and industrial landings

Trends in international landings of pelagic and industrial species between 1985 and 2013 show fluctuations until mid 00s and a decline since then. The highest volume has traditionally been caught by Norway, but now similar volumes are caught by the UK, Ireland and the Netherlands.



▲ International landings of pelagic and industrial species in NWW, country codes are NO= Norway; UK= United Kingdom; IE= Ireland; NL= Netherlands; FO=Faroe Isles; DE= Germany; DK= Denmark; FR= France; RU= Russia and IS= Iceland(ICES Catch Statistics from FAO FishStat Plus).

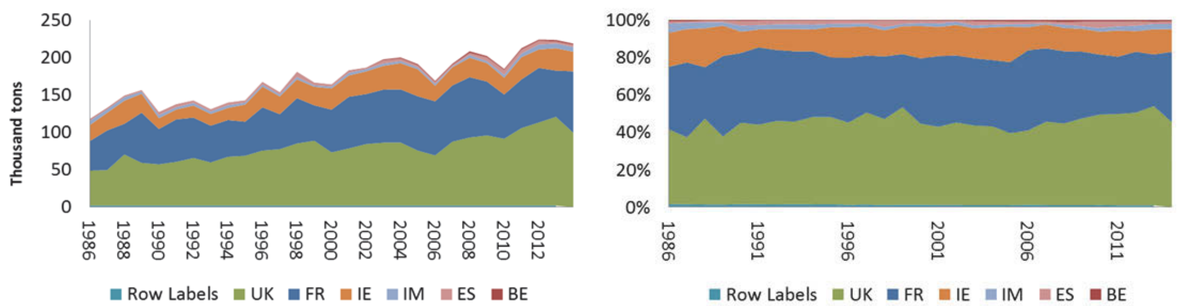
Shellfish: The top ten shell fish species in the NWW for 2013 are shown below.

	Great Atlantic scallop	Norway lobster	Queen scallop	Edible crab	Whelk	Cuttle fish & Squid	Blue mussel	Spinous spider crab	Euro pean lobster	Velvet swimming crab
ICES VI total	**4562**	**12872**	**2430**	**9561**	**623**	**558**	**0**	**0**	**263**	**602**
France	0	0		0		42		0	0	0
Ireland	12	6	144	2487	439	23	0	0	21	1
Isle of Man	117		0							
UK	4433	12866	2286	7074	184	493	0	0	242	601
ICES VII total	**50506**	**16106**	**18845**	**17514**	**29863**	**13847**	**8106**	**3819**	**1817**	**619**
Belgium	615	14		147	47	533			1	
France	27577	674	2272	3613	12157	8592	3081	2961	427	100
Gurnsey	150			786	3	2		35	110	
Ireland	2845	8429	2	2743	2216	187	3589	229	353	365
Isle of Man	1338	3	3567	733	499	7		1	45	
Jersey	280			358	253	3		77	198	
UK	17701	6986	13004	9134	14688	4523	1436	516	683	154
NWW total: 192513	**55068**	**28978**	**21275**	**27075**	**30486**	**14405**	**8106**	**3819**	**2080**	**1221**

Shellfish Fisheries in NWW

Shellfish fisheries in VI and VII are dominated by vessels specialising in *Nephrops,* scallop and crab. *Nephrops* fisheries occur on fine sediment fishing grounds west of Scotland, the Irish Sea, Celtic Sea and west of Ireland. France has highly productive and valuable inshore scallop grounds in Normandy while they are also important, west of Scotland and in the Channel. In Ireland, most scallops are landed from the eastern Celtic Sea.

Except for *Nephrops*, shellfish stocks in NWW are not regulated through TACs by the CFP, but crab and scallops are managed by the Western water effort management regime. Other species are managed nationally through licencing, effort and TAC regulation, minimum sizes and closed seasons. In NWW, landings of shellfish have been steadily increasing in the last 30 years.



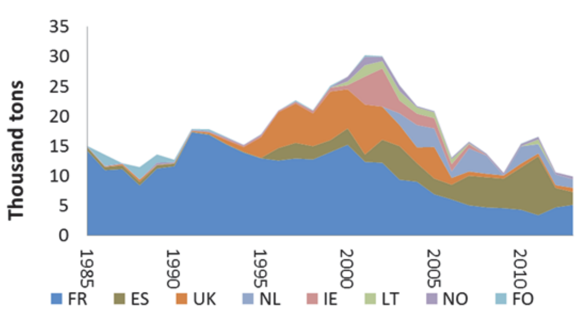
▲ International landings of shellfish species in NWW between 1985 and 2013, country codes are UK= United Kingdom; FR= France; IE= Ireland; IM= Isle of Man; ES= Spain and BE=Belgium (ICES Catch Statistics from FAO FishStat Plus).

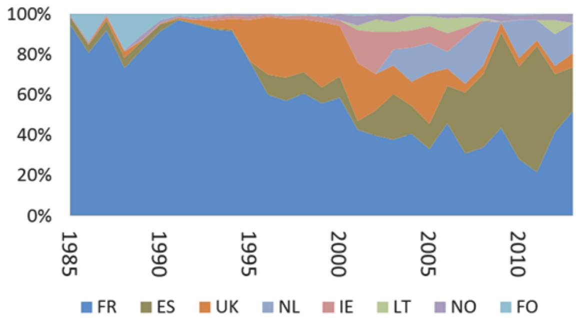
Deepwater Species: The top 10 deepwater species landed in 2013 in the NWW are shown below.

	Black scabbar dfish	Great. argent	Blue ling	Great. Fork beard	Round nose grenadier	Black belly rosefish	Baird's slickhead	Green land Halibut	Silver scabbar dfish	Atlantic redfishes
ICES VI total	**1912**	**1430**	**1503**	**780**	**1175**	**131**	**304**	**208**	**225**	**92**
Spain	46		31	19	235	59	304	0	225	0
France	1809	0	1137	252	934	48	0	114	0	70
Netherl.	0		0	1	0	5		0	0	0
Ireland	0	1430								0
Norway		0	132	289	0	0		1		0
UK	57	0	203	219	6	19		93	0	22
ICES VII total	**199**	**0**	**143**	**807**	**40**	**516**	**0**	**0**	**0**	**39**
Spain	10		107	550	0	386	0		0	3
France	189	0	35	209	40	70		0	0	36
Ireland	0		0	15	0	6	0	0	0	0
UK	0	0	1	33	0	54	0	0	0	0
NWW total: 9504	**2111**	**1430**	**1646**	**1587**	**1215**	**647**	**304**	**208**	**225**	**131**

Deep Water Fisheries in NWW

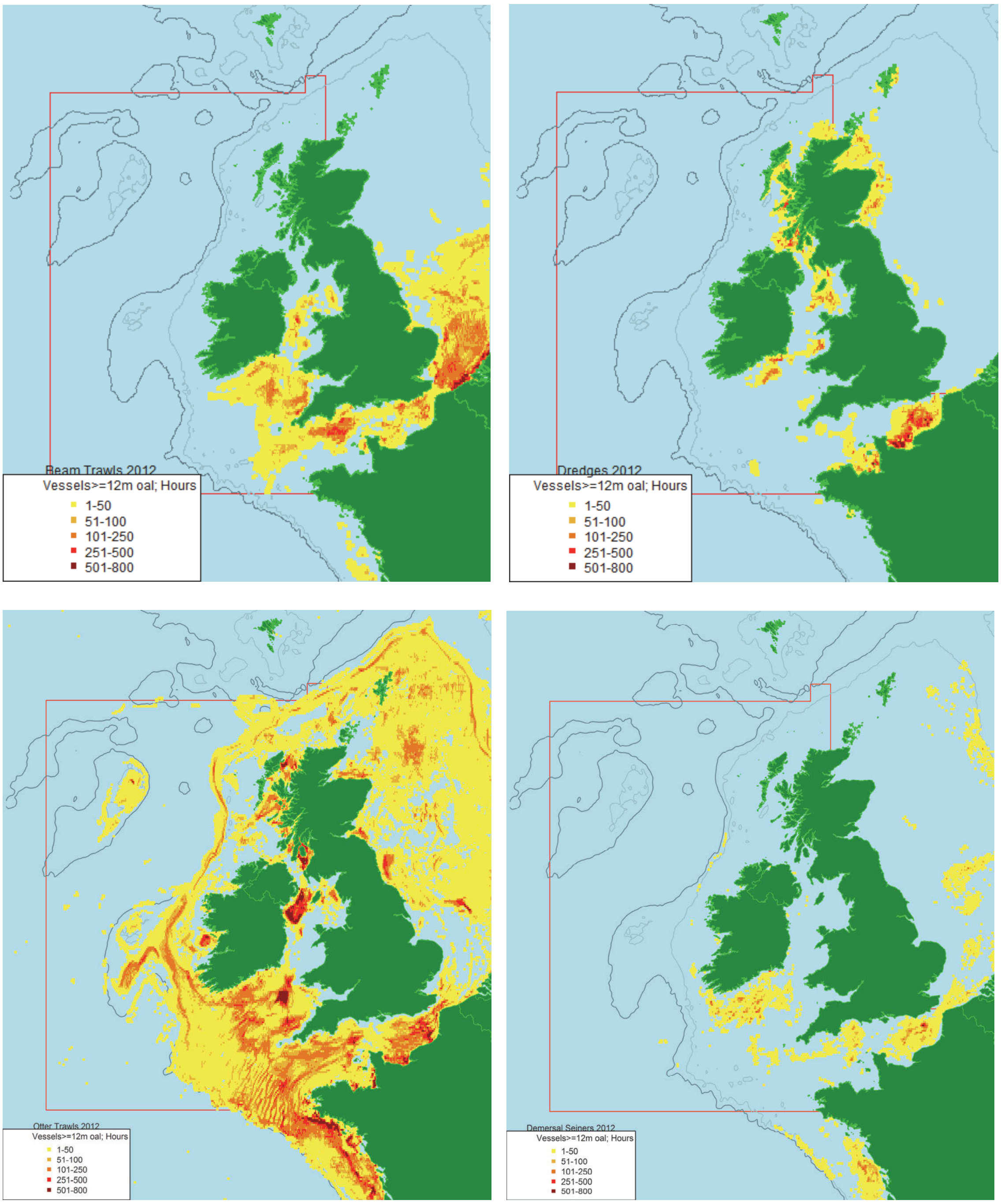
NWW have been subject to deep water fishing activity along the continental slope to depths of 1,500 m. Landings have peaked in early 2000s and decreased since. While deep water species still present opportunities for fishing fleets in NWW, with increased fuel prices, declining stocks, low TACs and sustainability issues, their contribution to overall landings are minor.





▲ International landings of deepwater species in NWW from 1985 to 2013, country codes are FR= France; ES= Spain; UK= United Kingdom; NE= Netherlands; IE= Ireland; LT: Lithuania; NO= Norway and FO= Faroe Isles (ICES Catch Statistics from FAO FishStat Plus).

Distribution of International fishing effort in 2012 by gear

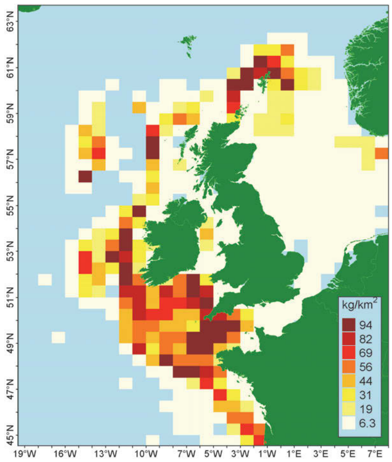


▲ Spatial distribution of international fishing effort by gear type in NWW in 2012, as monitored by VMS; only bottom contacting gear is shown. Data is based on data submitted by Belgium, Denmark, France, UK, Germany, Ireland, Netherlands, Norway, Portugal, and Sweden - Source: ICES 2014.

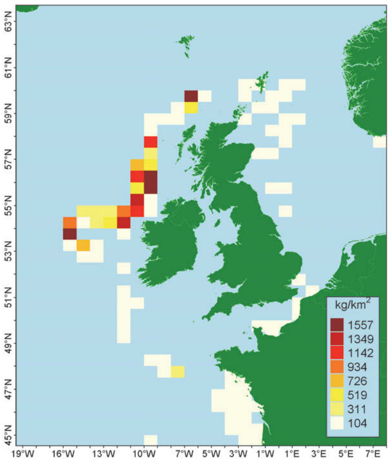
Distribution of fishing effort by different gear shows distinct spatial patterns with otter trawling being the most wide spread gear in NWW. Beam trawling is concentrated in the Channel, the eastern Celtic Sea and the Irish Sea, while dredging occurs in concentrated patches west of Scotland, the eastern Irish Sea, the Channel and southeast of Ireland. Demersal Seining occurs mainly in the Celtic Sea and the Channel.

Species landings by rectangle in 2013 (all gears)

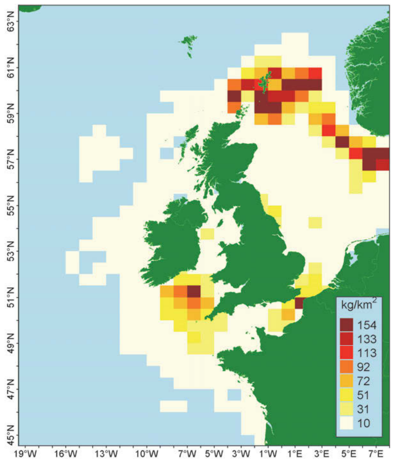
Anglerfish



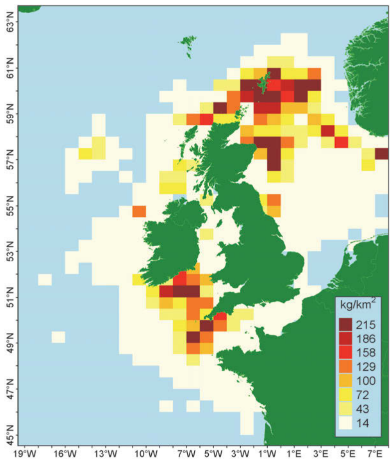
Blue Whiting



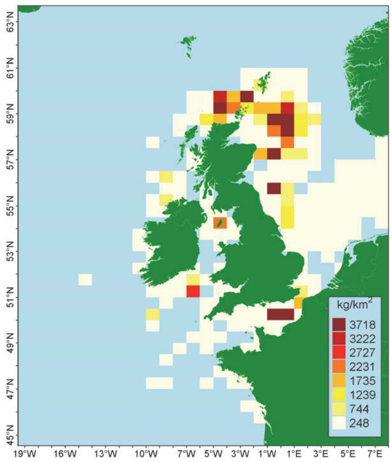
Cod



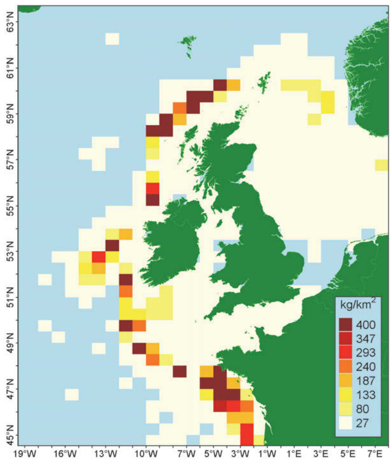
Haddock



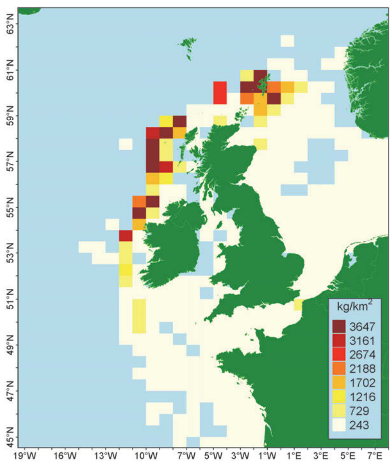
Herring



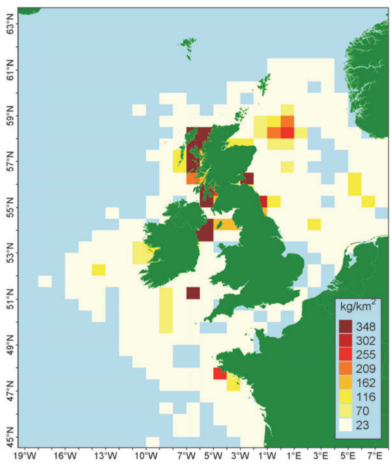
Hake



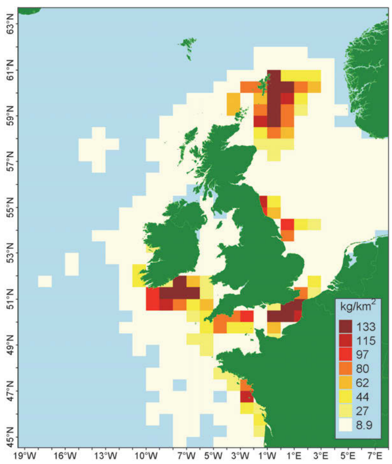
Mackerel



Nephrops



Whiting

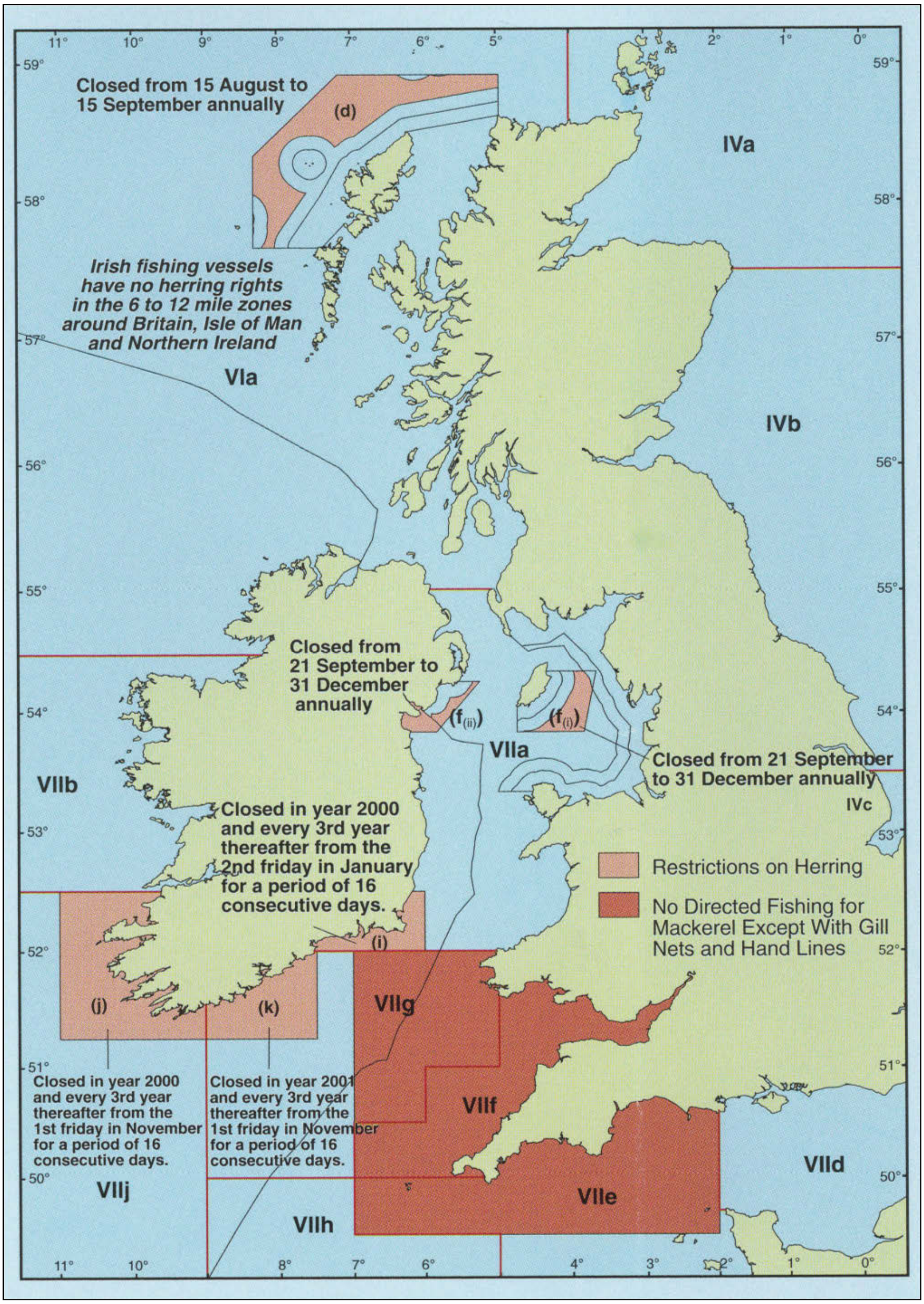


(Adapted from Gerritsen and Lordan, 2014 data from STECF database)

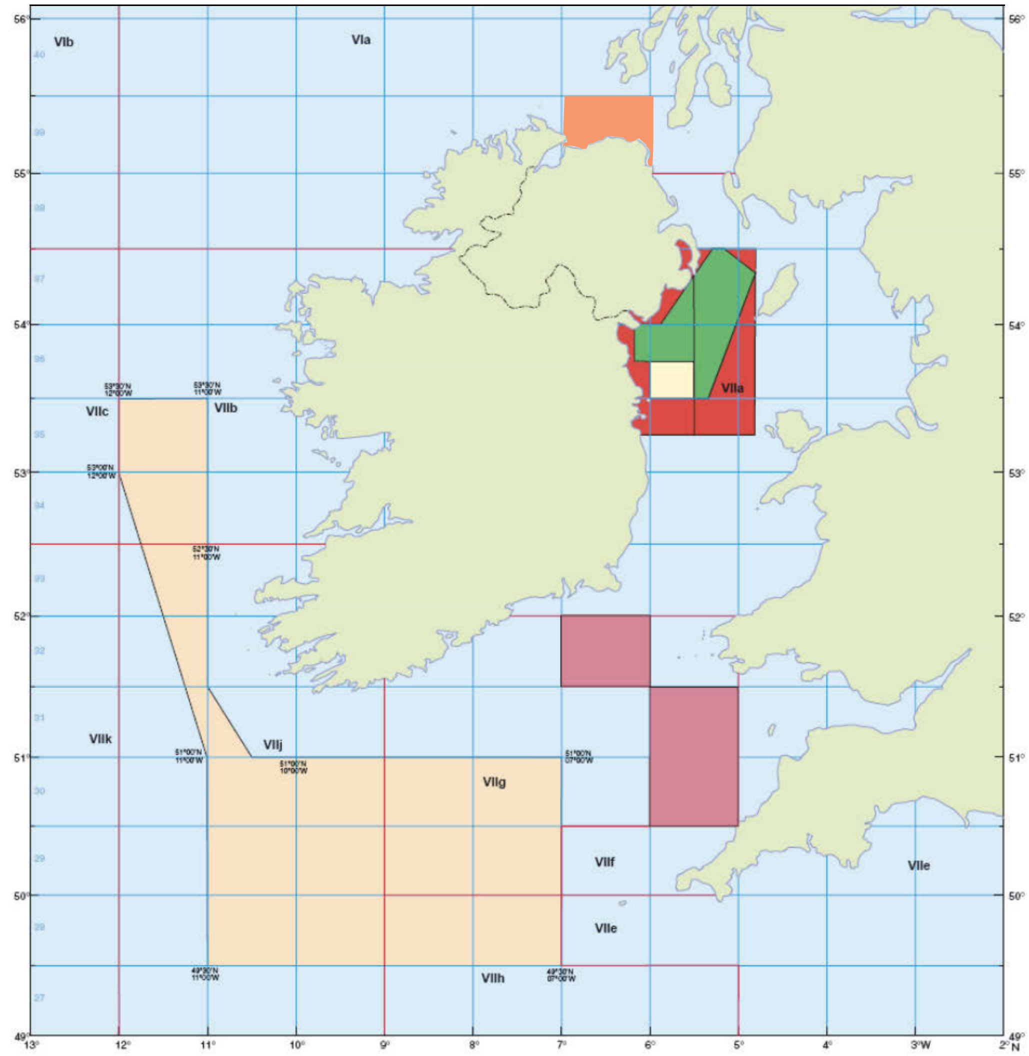
Spatial fisheries management measures

There are many protected areas and fishing restrictions in place for NWW. The following maps provide a brief overview of the main protected areas and restrictions and are reproduced courtesy of Board Iascaigh Mhara (Irish Sea Fisheries Board).

Mackerel and Herring Restrictions:



Cod and hake recovery boxes



IRISH SEA COD BOX (EU regulation 227/2013)

Closed to all fishing with any demersal trawl, seine or similar towed net, any gill net, trammel net or similar static net or any fishing gear incorporating hooks from the 14th of February to 30th April.

Fishing is permitted with a prawn net in the areas of the closed boxes coloured green provided:
A minimum of 35% live weight of prawns is on board;
• No other type of gear is carried on board.;
• Only one mesh size range is carried on board, 70-79mm or 80-99mm;
• No mesh in any part of the net is greater than 300mm

Fishing is permitted with a prawn net in this areas provided that in addition to the above:
It complies with the provisions made for the green zone;
• It included an inclined separator panel.

CELTIC SEA CONSERVATION AREA (EU regulation 227/2013)

From 1st February to 31st of March the highlighted areas are closed to all fishing except with pots and creels provided no fish other than shellfish are retained on board or Pelagic trawls with a codend mesh size of ≤55mm provided no fish other than herring, mackerel, pilchard/sardines, sardinelles, horse mackerel, sprat, blue whiting and argentines are retained on board.

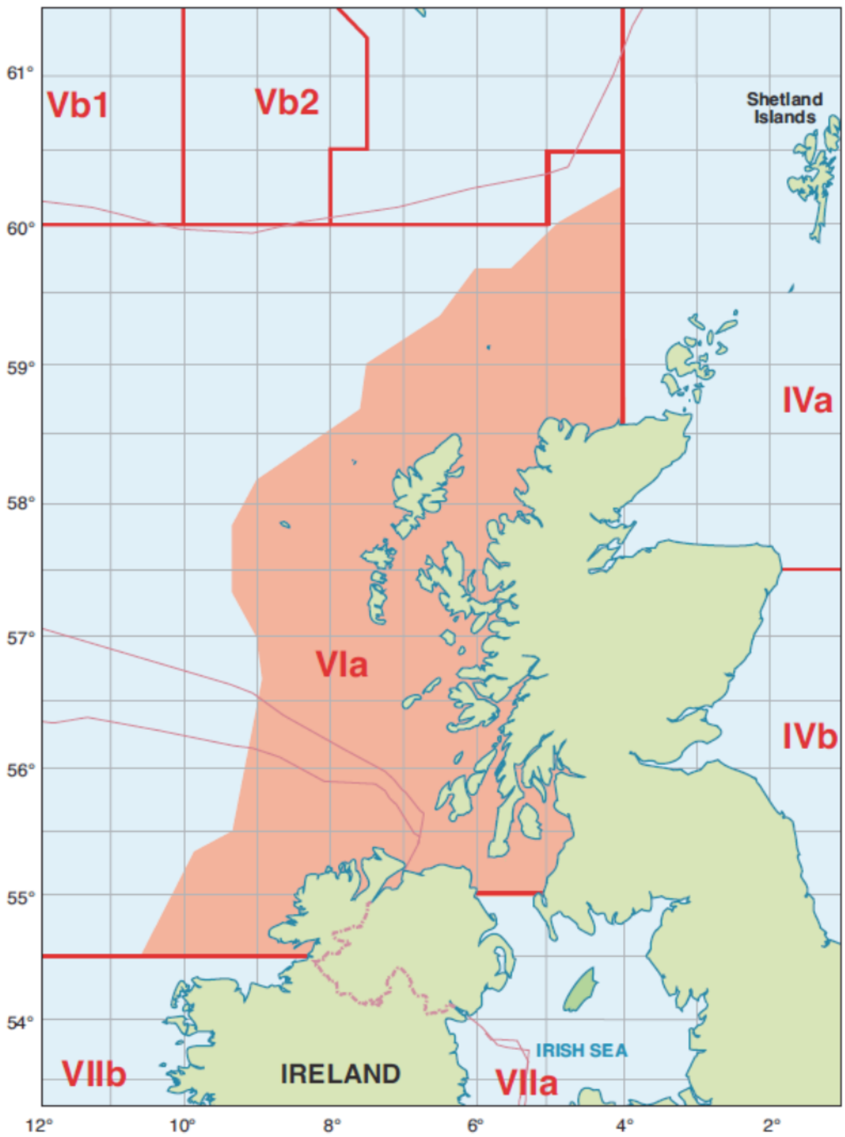
HAKE BOX (EU regulation 1162/2001)

Within this area a minimum mesh size of 100mm must be used for all towed gears and a minimum mesh size of 120mm used for all gillnets, entangling and trammel nets. Beam trawls of between 55-99mm maybe used east of 7° 30' west in the period April to October.

Closed to Cod

(Map courtesy of B.I.M.)

Restrictions on Fishing for Cod, Haddock and Whiting in ICES Area VIa



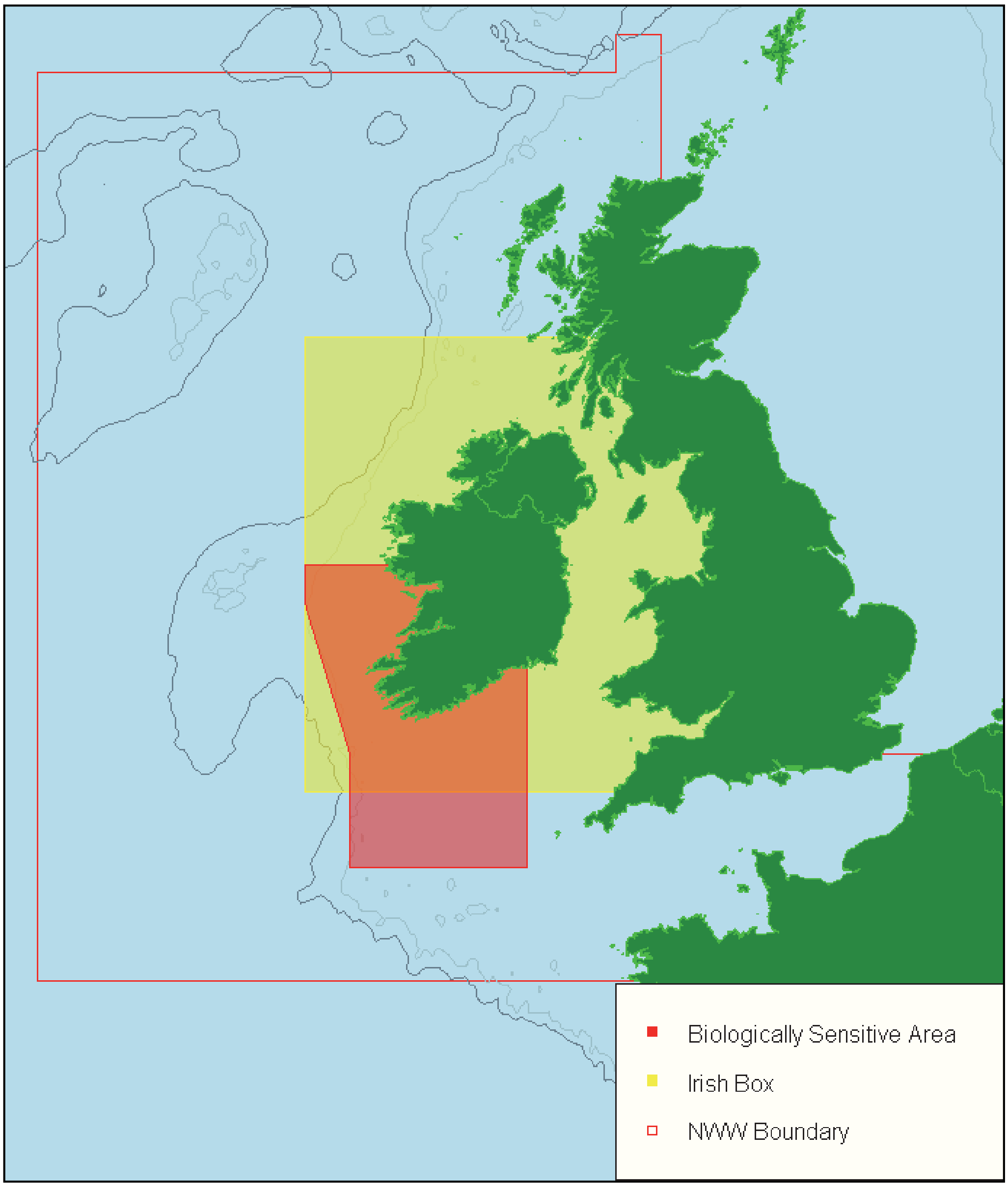
Restrictions on fishing for cod, haddock and whiting in ICES sub-area VI
(Summary from Regulation 227/2013, consult regulation for further details)

No fishing activity for cod, haddock and whiting within the orange marked area with the exception of fishing activities:

- using inshore static nets fixed with stakes, scallop dredges, mussel dredges, handlines, mechanised jigging, draft nets and beach seines, pots and creels, provided no fish other than mackerel, pollack, saithe and salmon, or shellfish other than molluscs and crustaceans are retained on board, landed or brought ashore;
- using nets with a mesh size of less than 55 millimetres and no fish other than herring, mackerel, pilchard/sardines, sardinelles, horse mackerel, sprat, blue whiting, boarfish and argentines are retained on board;
- using gillnets of mesh size greater than 120 millimetres, deployed in the area south of 59° N; with a maximum length of gillnet of 20 km per vessel, a maximum soak time of 24 hours; and no more than 5 % of the catch is made up of whiting and cod;
- using gillnets with a mesh size greater than 90 millimetres, deployed within 3 nautical miles of the coastline, for a maximum of 10 days per calendar month; with a maximum length 1 000 metres of gillnet deployed and the maximum soak time is 24 hours; and at least 70 % of the catch is made up of lesser spotted dogfish;
- for Norway lobster with fishing gear which incorporates a sorting grid or a square-mesh panel or other gear with equivalent high selectivity, the fishing gear is constructed with a minimum mesh size of 80 millimetres and at least 30 % of the retained catch by weight is Norway lobster.
- with trawls, demersal seines or similar gears with nets with a minimum mesh size of 120 millimetres for vessels > 15 metres and of 110 millimetres for all other vessels, and fishing gear incorporates a square mesh panel (in case of vessels <15m, if catch is < 90 % saithe).

From 1 January to 31 March, and from 1 October to 31 December each year, it shall be prohibited to conduct any fishing activity using any of the gears specified in Annex I to Council Regulation (EC) No 1342/2008 of 18 December 2008 establishing a long-term plan for cod stocks and the fisheries exploiting those stocks (**) in the area specified.

The Biologically Sensitive Area (BSA)



The Biologically Sensitive Area (BSA) is situated off the west and south coasts of Ireland and is considered to be an area of high ecological importance for different life history stages of fish. It contains important spawning and nursery grounds for exploited Northeast Atlantic fish species and is an area subjected to high commercial fishing activity. The BSA was established under Article 6 of Council Regulation No. 1954/2003, and replaced the Irish box which was set up under the Iberian Act of Accession 1986, in order to protect the area from increased fishing pressure. The BSA comprises parts of ICES Divisions VIIb, VIIg VIIj and VIIh. There are specific effort measures in place for the BSA.

14

MARICULTURE

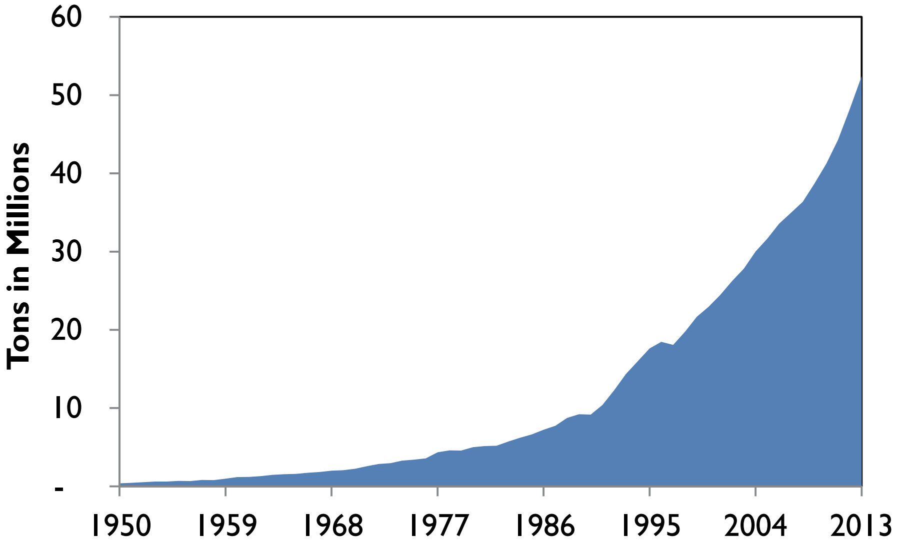
Key Points

According to FAO, the UN Food and Agriculture Organization, aquaculture is probably the fastest growing food-producing sector and now accounts for nearly 50 percent of the world's food fish. This trend is mainly driven by freshwater farms in south-east Asia.

The extent and volume of marine aquaculture (mariculture) is also increasing in NWW and three species dominate: Atlantic salmon, blue mussel and Pacific cupped oyster.

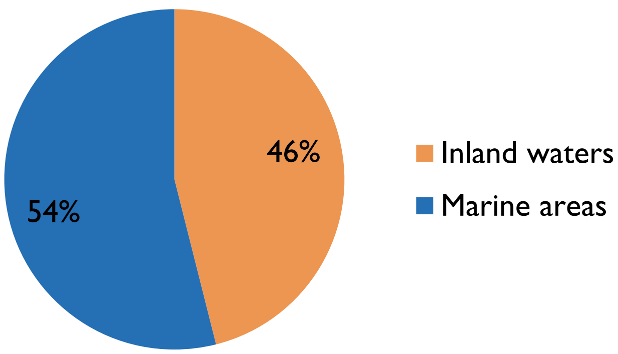
In 2013, UK was the largest aquaculture producer in the NWW and its production volume has increased drastically since the nineties. France, the second largest producer has had stable production volumes since the seventies.

According to FAO, the UN Food and Agriculture Organization, aquaculture is probably the fastest growing food-producing sector and now accounts for nearly 50 percent of the world's food fish. This trend is mainly driven by freshwater farms in south-east Asia.



▲ Annual increase in global aquaculture production from 1950 to 2013 (Data source: FAO Fishstat).

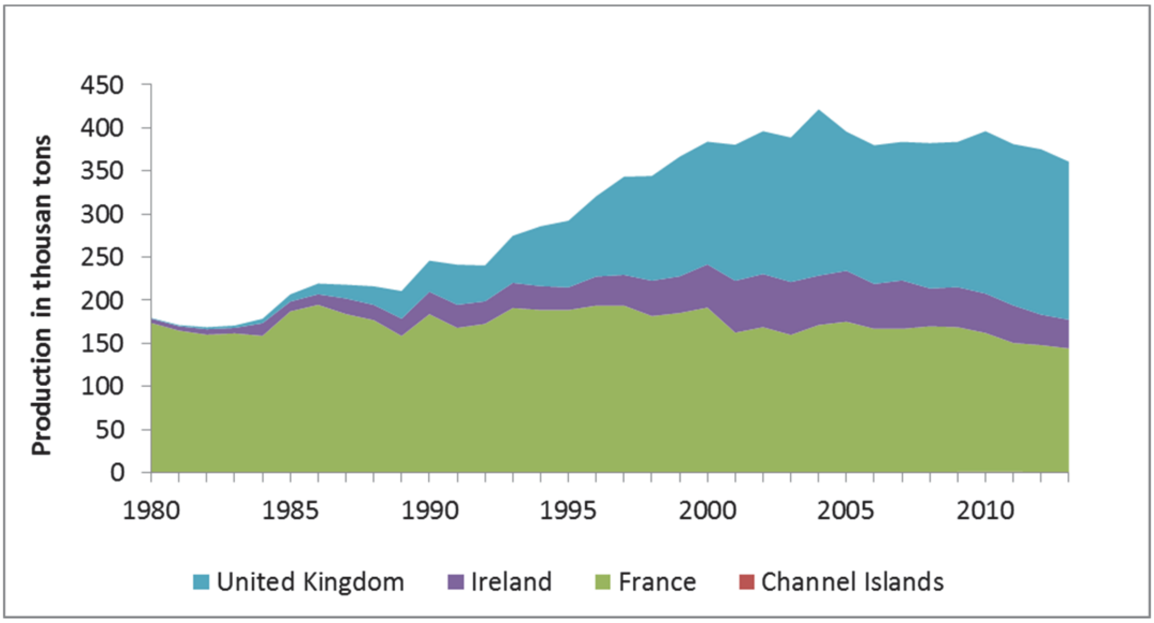
▸ Feeding barge at fish cages, west of Ireland.



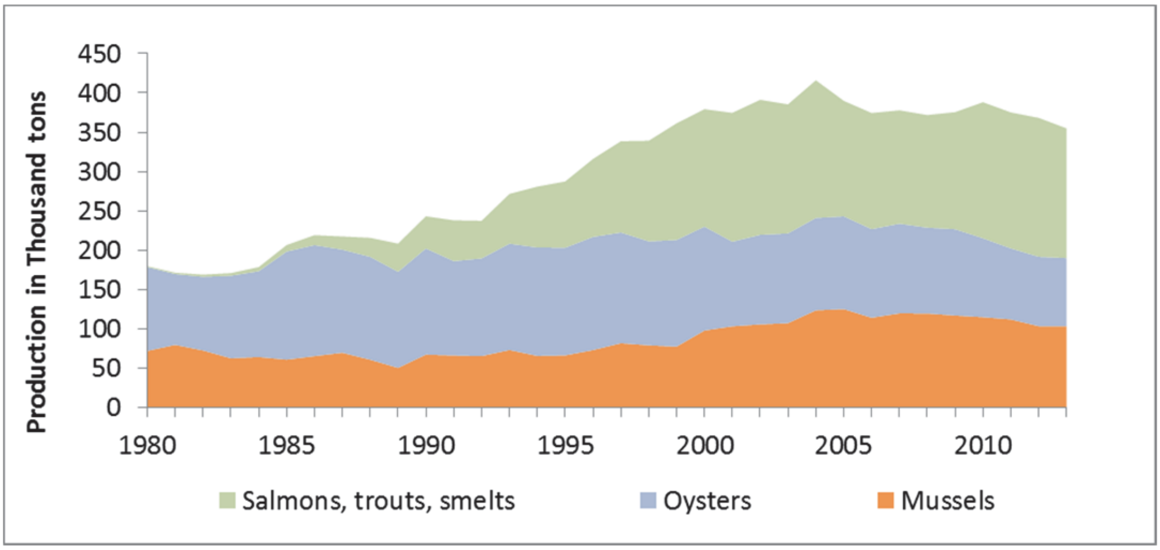
◂ Global annual aquaculture production by ecosystem in 2013, aquaculture in marine waters make up more than half of total production (Data source: FAO Fishstat).

European figures also show a substantial increase in marine aquaculture (mariculture) in the NWW.

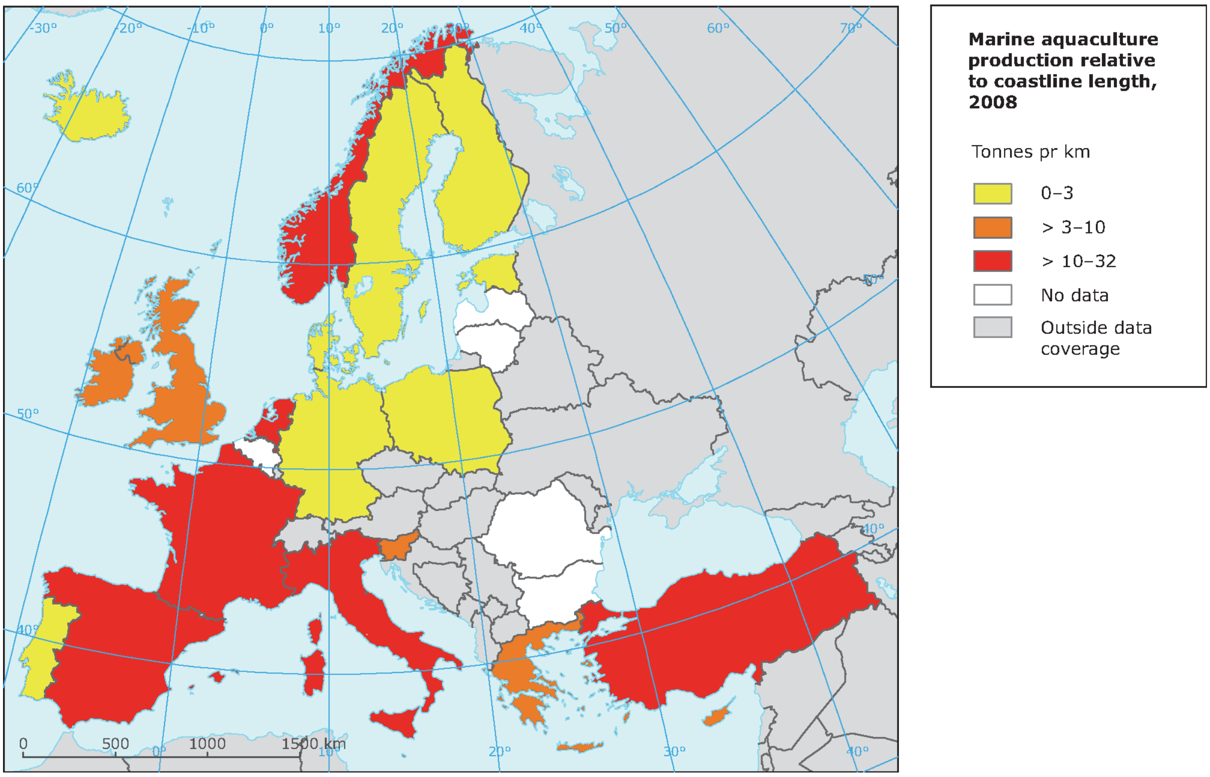
Three species dominate mariculture in the NWW countries: Atlantic salmon, Blue mussel and Pacific cupped oyster. The last quarter of a century has seen a huge increase in salmon farming in the area, from almost nothing in the early 1980s to the largest share of the total 2013 mariculture production. In NWW, the main fish farming country is UK-Scotland and the main shellfish farming country is France.



▲ Annual aquaculture production by nation in the NWW (Source: FAO FishStat). Note: As data is aggregated by country, this graph includes some areas that are outside NWW.



▲ Annual production of the top 3 species groups farmed in the Channel Islands, France, Ireland and the United Kingdom (Source: FAO FishStat). Note: As data is aggregated by country, this graph includes some areas that are outside NWW.



▲ Production of Finfish and Shellfish per Km of coastline in 2008 (Source: EEA, 2010).

Blue Mussel Farming

One way of rearing blue mussels is by rope. Seed mussels (spat) are harvested from wild beds and used to populate ropes suspended from floating structures in sheltered coastal areas. The mussels attach to the rope using byssal threads and filter their food from the passing water, reaching marketable size in two years.

▲ Image Source: SuperStock.co.uk

DISTRIBUTION OF OTHER HUMAN ACTIVITIES

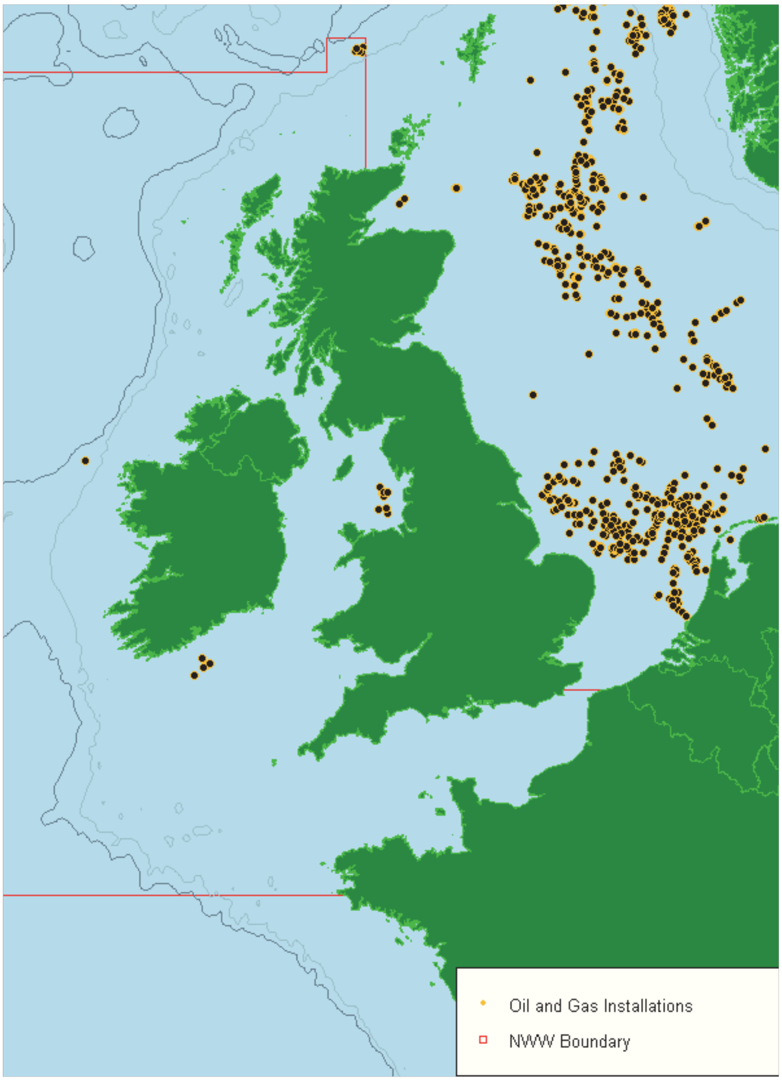
Key Points

NWW are subject to a broad range of human activities. There is a network of fishing, commercial and leisure ports and harbours along its coastline, and wide and varied impacts stemming from large coastal cities and towns (e.g. power plants, waste water refining stations, coastal infrastructure, etc.). There are busy shipping lanes leading from the Channel west and southwards. Submarine cables and pipe lines are also concentrated in the Channel and the Celtic Sea. Oil and gas prospecting and extraction occur in the Celtic Sea and west of Ireland while aggregate extraction is concentrated in the Irish Sea and English Channel. Navigational dredging is common in most shipping ports. Emerging pressures are those associated with increases in renewable energy production while marine tourism is widespread along NWW coasts.

The following maps are intended to give "an eagle eye view" of the various other human activities taking place in the NWW area and their potential impact on the marine environment.

Non-renewables (Oil & Gas)

The number of oil and gas installations in NWW waters is minor compared to the North Sea. Non-renewable structures (e.g. oil rigs and subsea installations) can cause a range of impacts from sealing of substrate and smothering from cuttings, to potential oil spills. Hard structures such as oil rigs can also provide a hard substrate for colonisation, creating a 'reef effect'. As such, the habitat is modified from the original habitat type, but may increase biodiversity. Seismic surveying is required for oil and gas exploration and together with drilling activities can impact upon marine environments through noise pollution. This can primarily result in the displacement of marine mammals and fish.



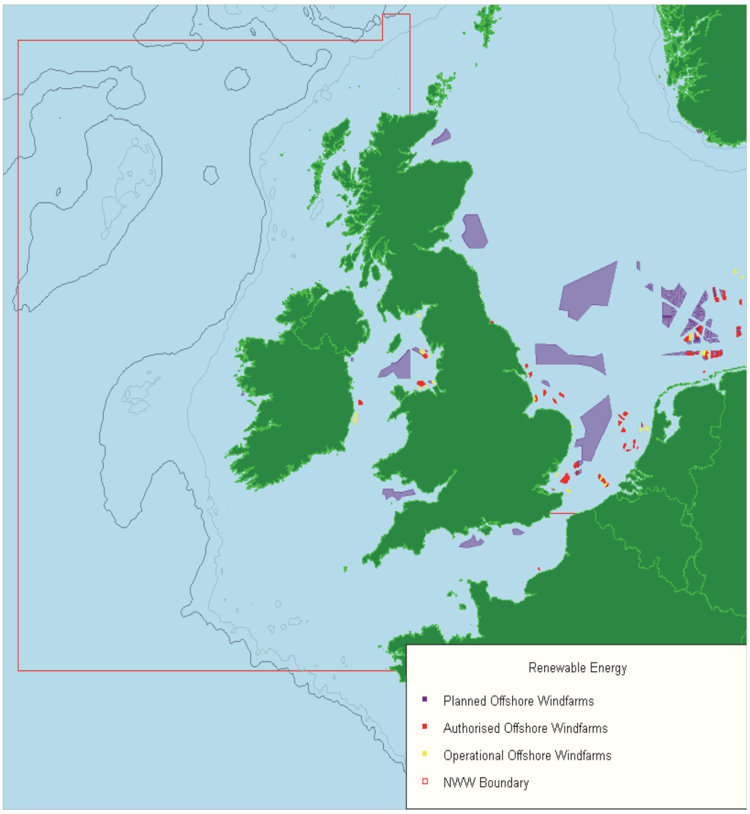
▲ Oil/gas offshore installations in the NWW in 2013 (Data courtesy of OSPAR Commission)

Hydrocarbon Spills

Oil spills can have widespread visible impacts on marine fauna, particularly birds and marine mammals. The effects of spills on the environment depend on a number of factors, such as the type and quantity of hydrocarbon spilt; weather conditions and the sensitivity of the area affected. The light fraction of oil tends to evaporate quickly and does not have longterm effects while the heavier fraction can bioaccumulate in sediment and biota resulting in changes in physiology, behaviour and reproduction. If the spill reaches land, it can become a larger problem for littoral organisms and sensitive environments such as mudflats, salt marshes and estuaries.

Renewable Energy

Renewable energy infrastructure continues to grow in NWW to solve increasing energy demands, and to support progress towards the targets of the EU Renewable Energy Directive (i.e. 20% of all energy by 2020). Despite environmental and sustainability benefits of renewables, construction and subsequent operation can have localised impacts on the environment through abrasion and scouring, substrate sealing, noise pollution, electromagnetic fields, changes to localised wave patterns, and acting as barriers for migrating bird species (particularly wind farms). Most of the impacts are minimised and/or mitigated for through adherence to national legislation and international agreements (e.g. OSPAR guidance documents). Renewable structures may also provide some degree of refuge for certain species, similar to the 'reef effect' observed with non-renewable structures.



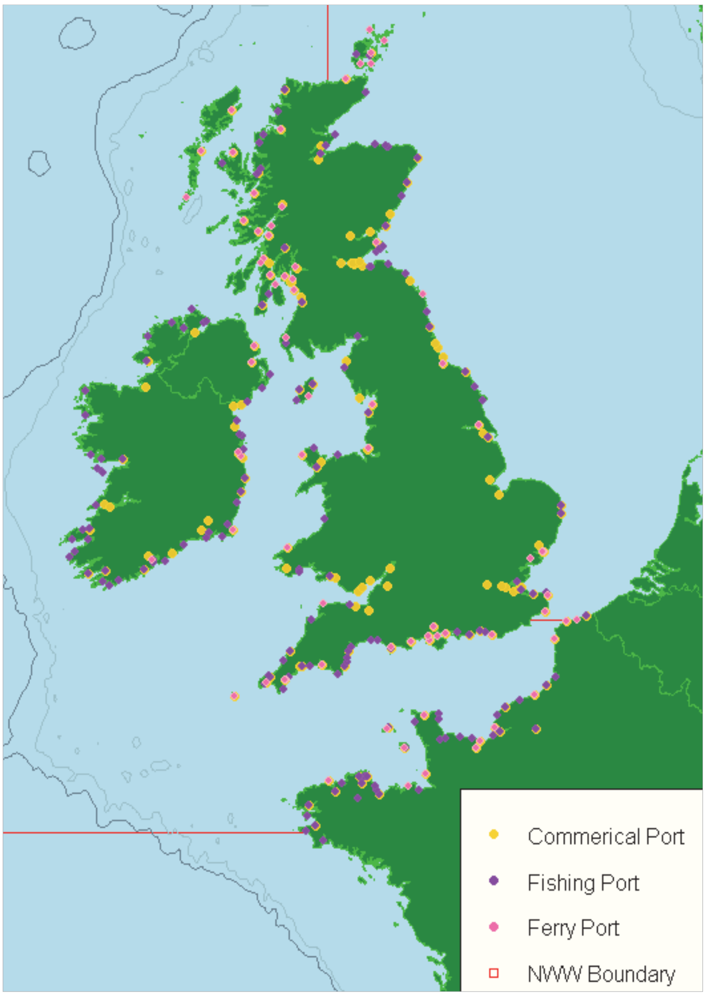
▲ Offshore wind-farms in the NWW in 2013 (Data courtesy of OSPAR Commission)

▲ Dominant shipping lanes in the NWW in 2013 (Source: http://www.arcgis.com)

Shipping and Commercial Activities

Shipping routes and ports are a key aspect of economic activities in NWW and shipping activity is predicted to increase in the coming decades (OSPAR, 2010). Potential environmental impacts are greenhouse gas emissions, noise and litter pollution, collisions with marine mammals, and introduction of contaminants and non-native species through discharges in ballast and waste water and through leaching.

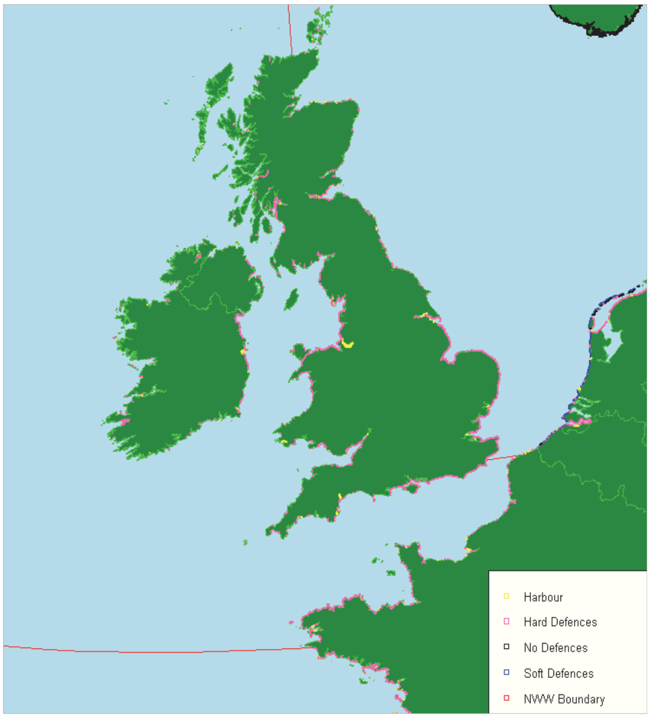
Coastal Infrastructure and Ports



▲ Location of ports along NWW coast. (Data combined from www.ports.org.uk; www.worldportsource.com and www.agriculture.gov.ie.)

Coastal infrastructure is essential to support and maintain commercial activities such as fishing, shipping, tourism and recreation through the provision of harbours, ports, coastal defences and safe access. Environmental impacts of construction activities include loss of seabed habitat (sealing), smothering, siltation, abrasion and noise pollution (OSPAR, 2010). The finished structures are associated with impacts such as loss of habitat, inputs of pollutants from ships, boats and terrestrial run-off. Ports are often located along estuaries, which are particularly subject to anthropogenic pressures.

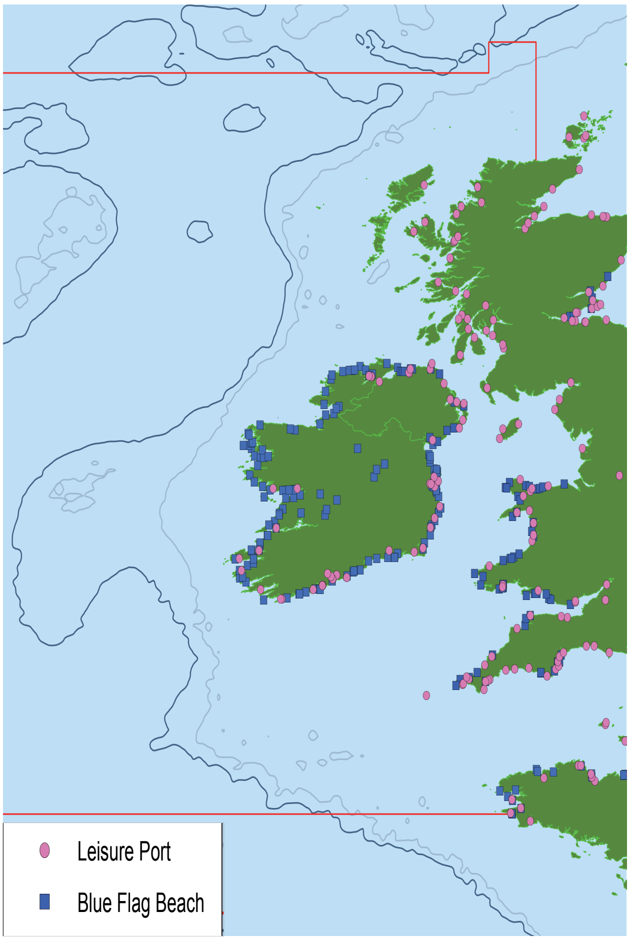
Coastal defensive structures occur extensively along NWW coasts in particular in Northwest England, East Ireland and West Brittany. They consist primarily of hard defences. As part of national and EU laws such as the Habitats Directive more natural techniques are now prioritised where possible (OSPAR, 2010).



▲ Coastal defences along NWW coast, 2010- (Data courtesy of OSPAR Commission)

Travel and Tourism

Coastal and marine tourism is widespread in NWW. Beach tourism and recreational boating can have direct effects on the marine ecosystem through disturbance, litter, pollution, coastal erosion as well as siltation and abrasion. Blue flag beaches provide an incentive for improved water quality.

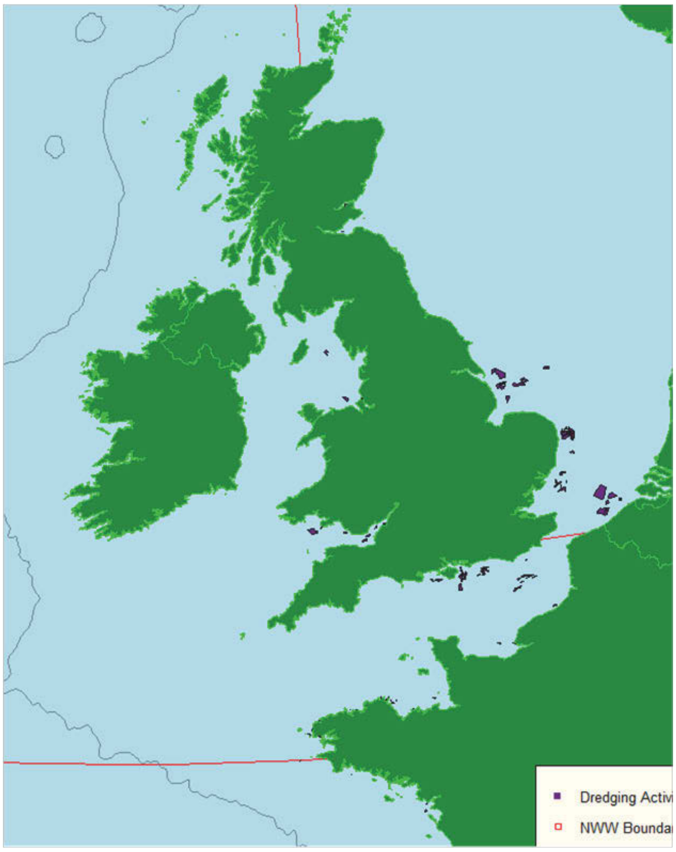


▲ Location of leisure ports and blue flag along NWW coast- (data combined from (http://www.blueflag.org and ports as above)

Land-based Industry

The principal issues surrounding land-based industry relate to run off from operations and water extraction. The primary contaminants of concern have been outlined in Chapter 6, however industrial effluents can also cause changes in salinity and thermal regimes, along with being a major contributor of microplastics. A multitude of EU and national legislation governs the inputs to water courses, including the banning of certain substances (e.g. a range of pesticides). However, for many components there is insufficient data on their biological and environmental effects.

Navigational Dredging and Dumping

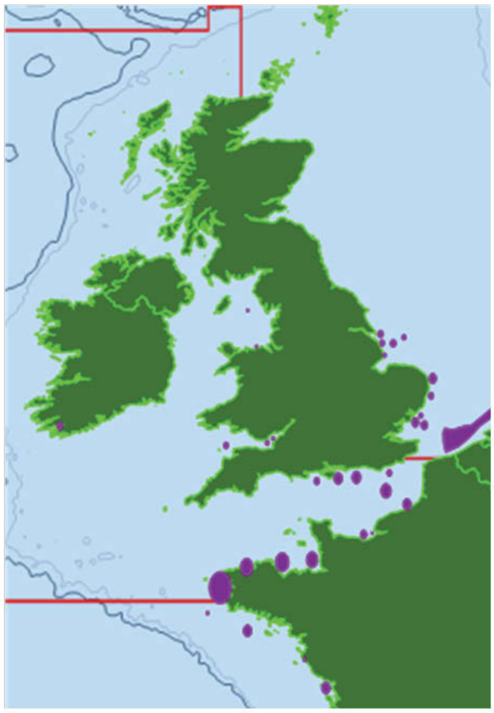


▲ Navigational dredging in NWW, 2010 (Data courtesy of OSPAR Commission)

99% of sediment dumped at sea is a result of navigational dredging (OSPAR, 2010). The majority of dredged materials are dumped at sea at designated sites, however some is beneficially reused. The most obvious effects of navigational dredging and the subsequent disposal of dredged material are increased turbidity, abrasion, smothering, siltation and noise. Contaminants bound in the sediments may also be released through the process. Natural materials such as fish waste and inert materials such as rocks may also be dumped at sea, however all are tightly regulated, through licence, control systems of contaminant load and selection of suitable dumpsites.

Mineral Extraction

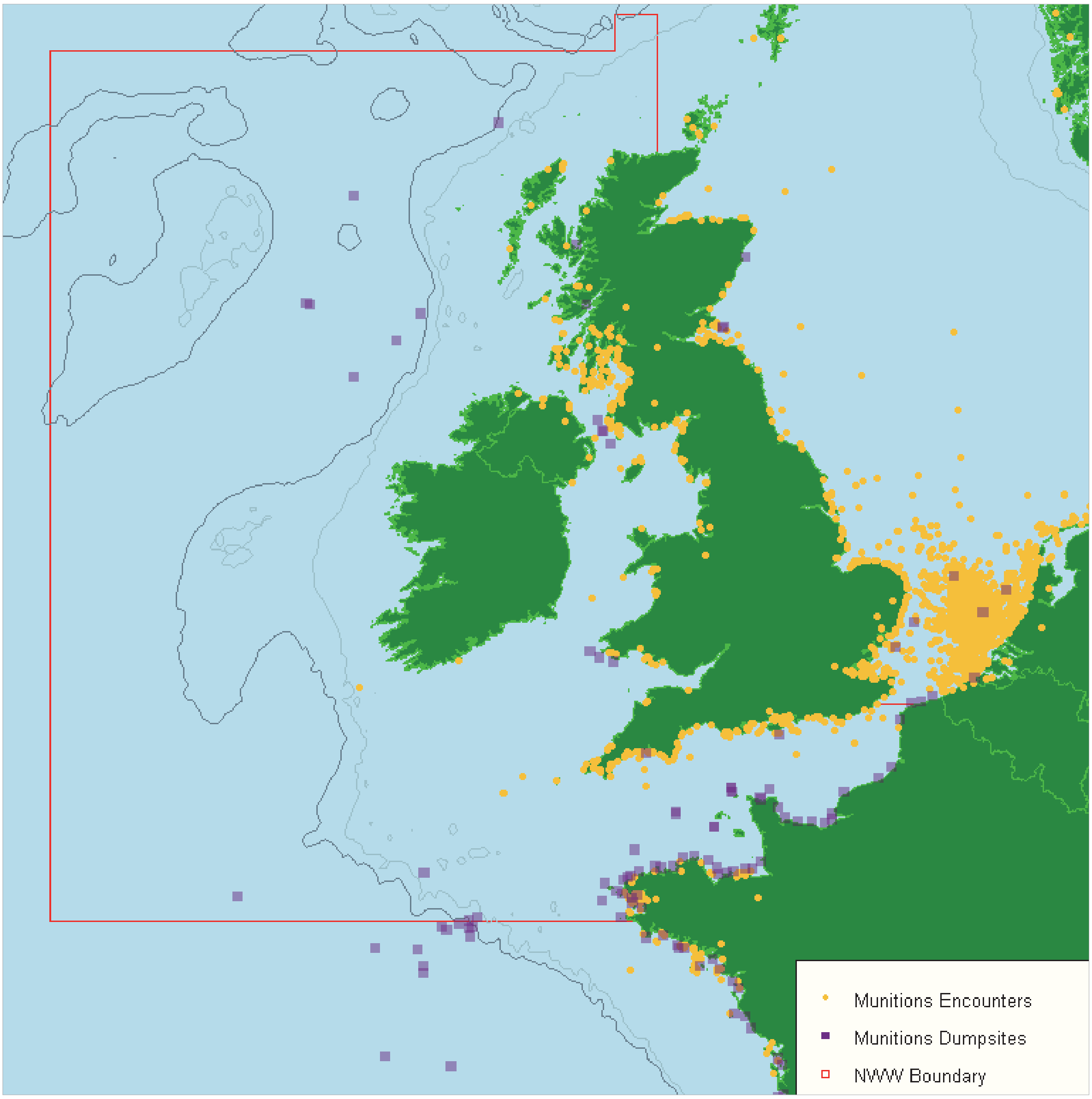
Sand, gravel and crushed rock, collectively known as 'aggregates' are essential raw materials for construction industries and beach replenishment schemes. Extraction of marine sand and gravel has increased by >30% in the last decade in the OSPAR area and is low in NWW compared to the North Sea (OSPAR 2010). Impacts of aggregate extraction are increased turbidity, removal of sediment and biota, abrasion, smothering, noise and loss of habitat. Recovery and recolonisation can be within 2-4 years after short term activities, but the seabed may take > 7 years to recover from intensive or protracted extraction operations (OSPAR, 2009). The EU EIA and Habitats Directives legislate to ensure vulnerable habitats are protected, and guidelines are provided by OSPAR and ICES.



▲ Mineral extraction in NWW coast, 2010 (Data courtesy of OSPAR Commission).

Military

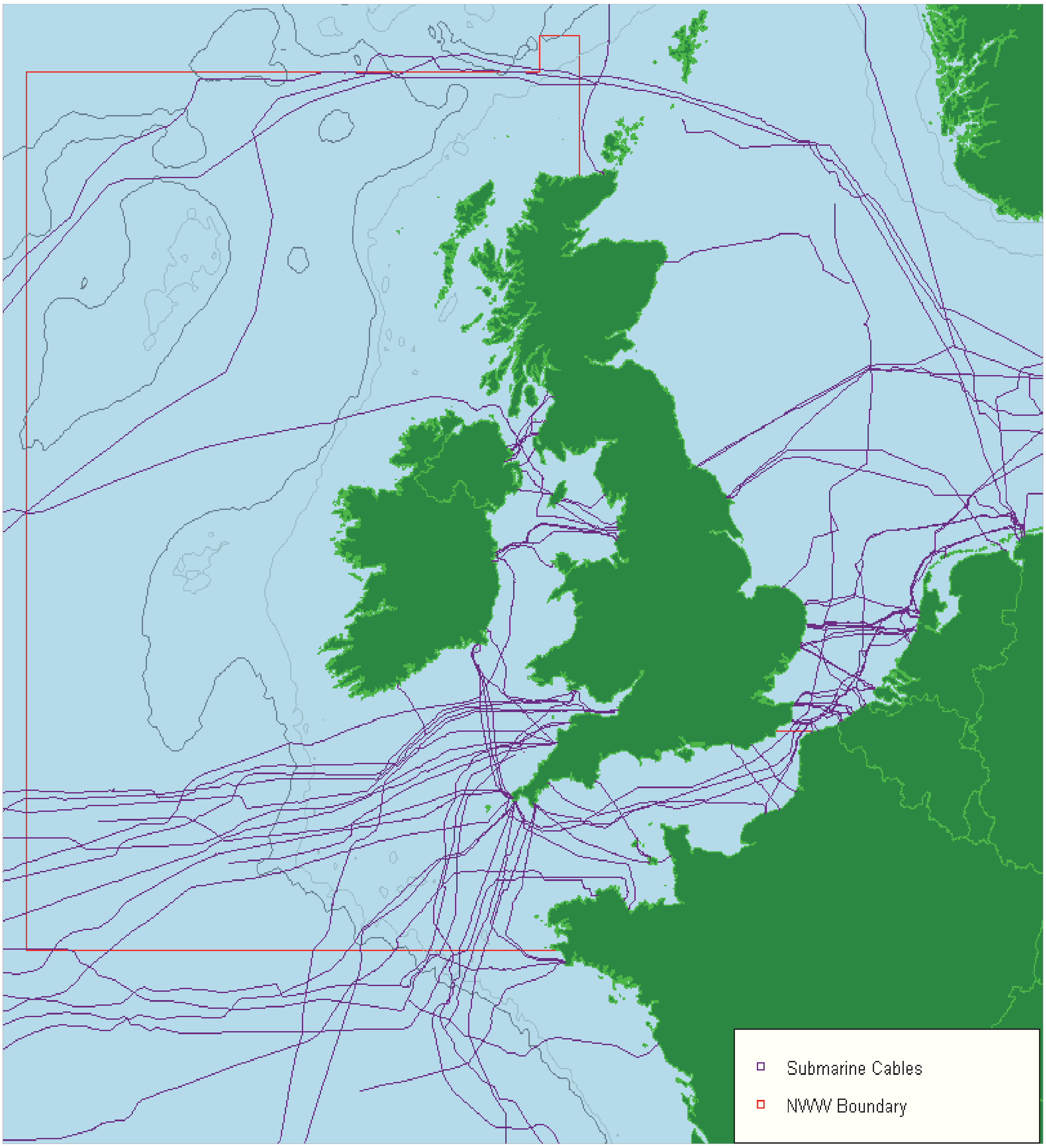
Military activity within the NWW varies in relation to country. There is minimal activity from Ireland, whereas UK exercises occur throughout extensive areas of their waters. Impacts primarily relate to the risk of spread of invasive species, and noise impacts on sensitive marine mammal species. Dumped munitions are a historical legacy. Along with the direct risks from potential explosion, the eventual degradation and release of toxins may affect marine species OSPAR monitors the encounters with munitions, most of which are conventional and are removed/ neutralised. Dumped munitions are primarily located along the French and UK coastlines, with chemical munitions dumpsites occurring in designated offshore sites.



▲ Munitions dumpsites and encounters in NWW, 2012 (Data courtesy of OSPAR Commission)

Submarine Cables and Pipelines

Cables and pipelines are a necessity for telecommunications, and both renewable and non-renewable energy supply. Although the number of telecommunications cables is expected to decrease with increasing reliance on satellite communications, cables associated with renewable energy installations are expected to increase (Merck and Wasserthal, 2009). Impacts are localised and mainly temporary (i.e. during installation). They include small scale thermal and electromagnetic pollution potentially affecting attraction, orientation and migration, particularly for electrosensitive species such as sharks and are more relevant to power transmission cables than telecoms cables. Pipelines can provide artificial hard substrates which allow the colonisation of species atypical to an area.



▲ Sub-marine cable distributions in NWW (Source www.kis-orca.eu)

◢ Litter Pollution on a Beach in Howth Co. Dublin

16

MARINE LITTER

Key Points

Marine litter can be defined as '*any persistent solid processed material which has been discarded or disposed of in the marine environment*', often including slowly degrading waste items such as plastics, metals and glass.

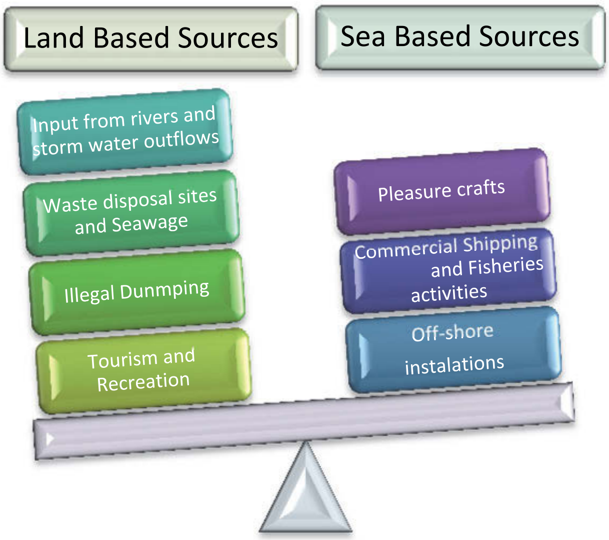
Sources of marine litter can be land based and sea based and range from large items like abandoned fishing gear or derelict fishing vessels to everyday disposable items such as plastic bags, tin cans, right down to microplastics. **Microplastics** are plastic particles <1mm in length that persist in the environment. Microplastics can derive from the breakdown of larger plastic items by mechanical and chemical erosion, cosmetic products, industrial abrasives and in synthetic fabrics, the fibers of which are flushed into the sewage systems with every clothes wash.

Marine litter can impact all marine environments in both ecological and economical terms. Marine litter can damage and/or kill marine life e.g. through entanglement and ingestions, and have harmful effects to human health when transferred up the food chain. Marine litter can cause the loss of potential income from ecosystem goods and services in activities such as marine tourism and fishing.

▲ Bottle found at almost 1000 meters depth among the deepwater corals

Litter on the Sea Floor

Litter is present in all marine habitats, from beaches to the most remote points in the oceans. On the seafloor, marine litter, mainly plastics, can accumulate in high density. In an extensive study on the distribution and density of marine litter in European waters, litter was found to be present in the deepest areas of the Atlantic Ocean and at locations as remote from land as the Charlie-Gibbs Fracture Zone across the Mid-Atlantic Ridge (Pham *et al*, 2014). The study showed highest litter density in submarine canyons, with litter from fishing activities (derelict fishing lines and nets) prevalent on seamounts, banks, mounds and ocean ridges whilst the lowest density was found on continental shelves and on ocean ridges. Plastic was the most widespread litter item found on the seafloor.

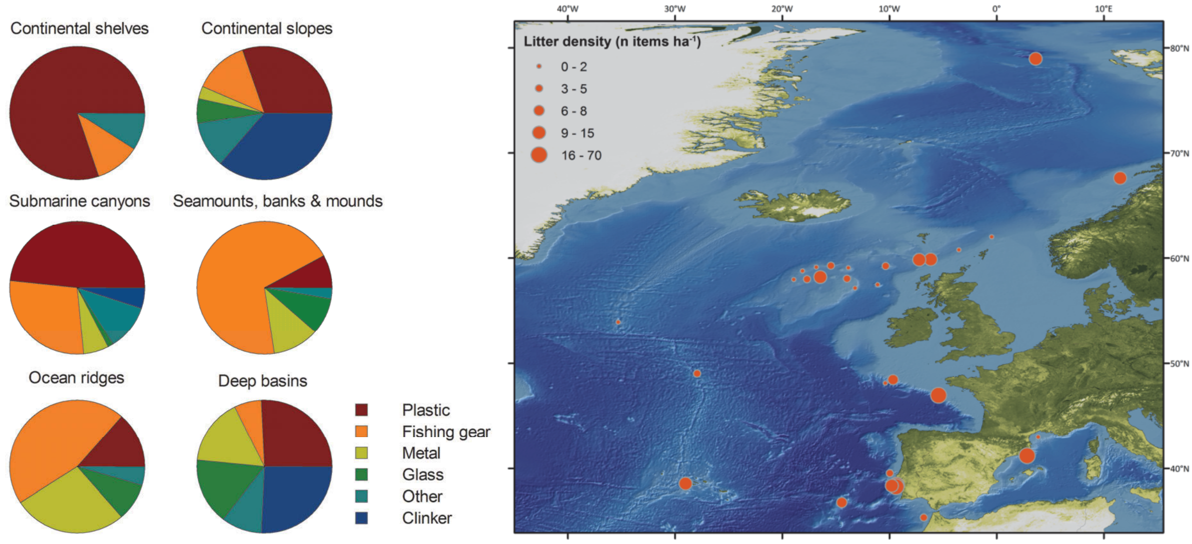


▲ Sources of litter from land and sea based human activities.

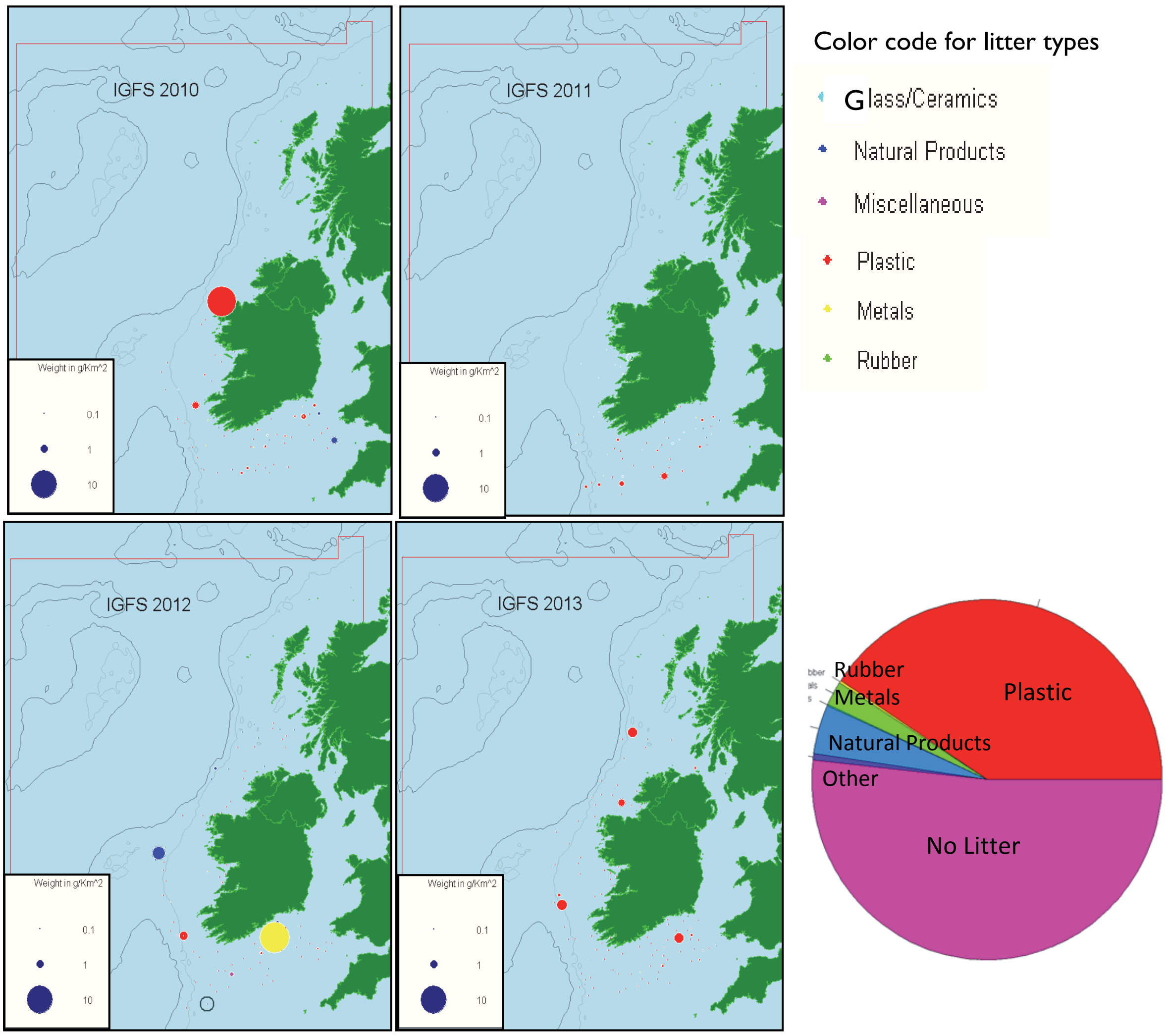
Monitoring for Marine Litter data: Fisheries Monitoring programs

Understanding the extent of the marine litter problem in NWW waters is hampered by a lack of monitoring data. Can other monitoring programmes such as fish surveys be used to collate data on marine litter?

Fisheries surveys are primarily carried out to collect information on the distribution and abundance of commercial fish species. Marine litter as caught in the trawl is now recorded on these surveys and quantified using the weight of each type of item collected per trawl (e.g. plastic, aluminum, glass, etc.). About 50% of all hauls contain some form of marine litter, indicating that marine litter is widespread with some areas where litter is found persistently. The prominent form of litter in the trawl is plastics. The data can inform on how much litter is collected in a particular trawl, but further work is needed to understand how representative the data is of the marine litter on the seafloor and the water column.



▲ Composition and density of marine litter in deep waters of Europe (Pham *et al*, 2014)

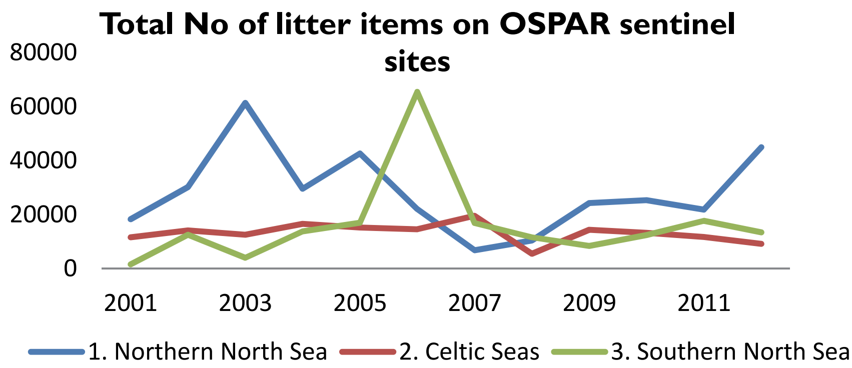


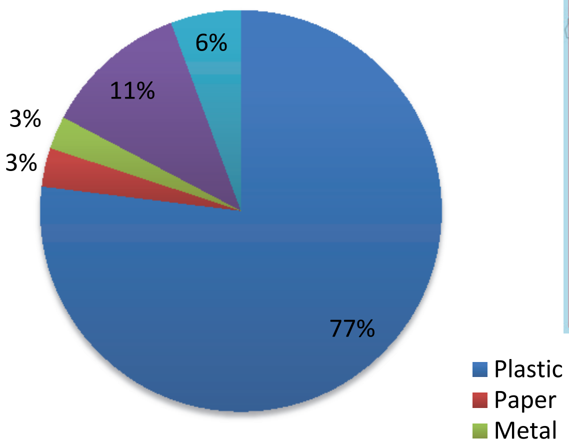
▲ Maps showing distribution of litter found in the hauls during the IGFS from 2010 to 2013. Pie chart shows the breakdown of litter types by haul over the 4 year period. The empty circle in 2012 represents an outlier (1 ton of fishing nets).

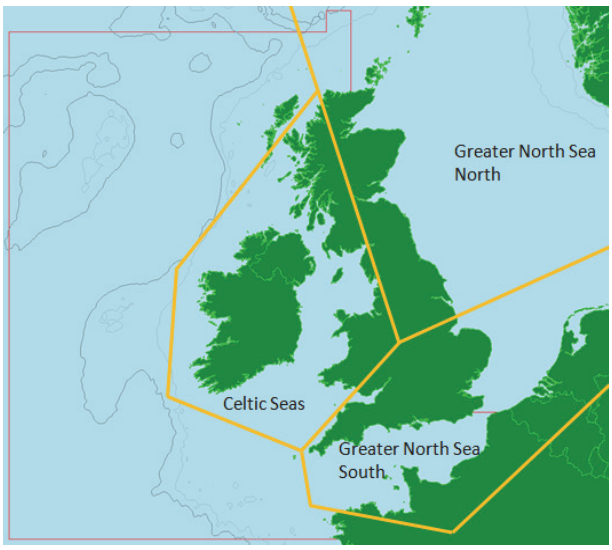
Coastal Litter

Coastal litter comes from a variety of sources including land based such as river input, illegal dumping and waste disposal sites, as well as sea based from shipping, fishing, pleasure crafts and offshore installation. Coastline litter data can be used as an indicator for marine litter pollution. OSPAR monitors the number of items collected at sentinel sites along the coastlines as part of its "Beach Litter Monitoring Programme".

▲ Seal tangled in tangle net, Mayo



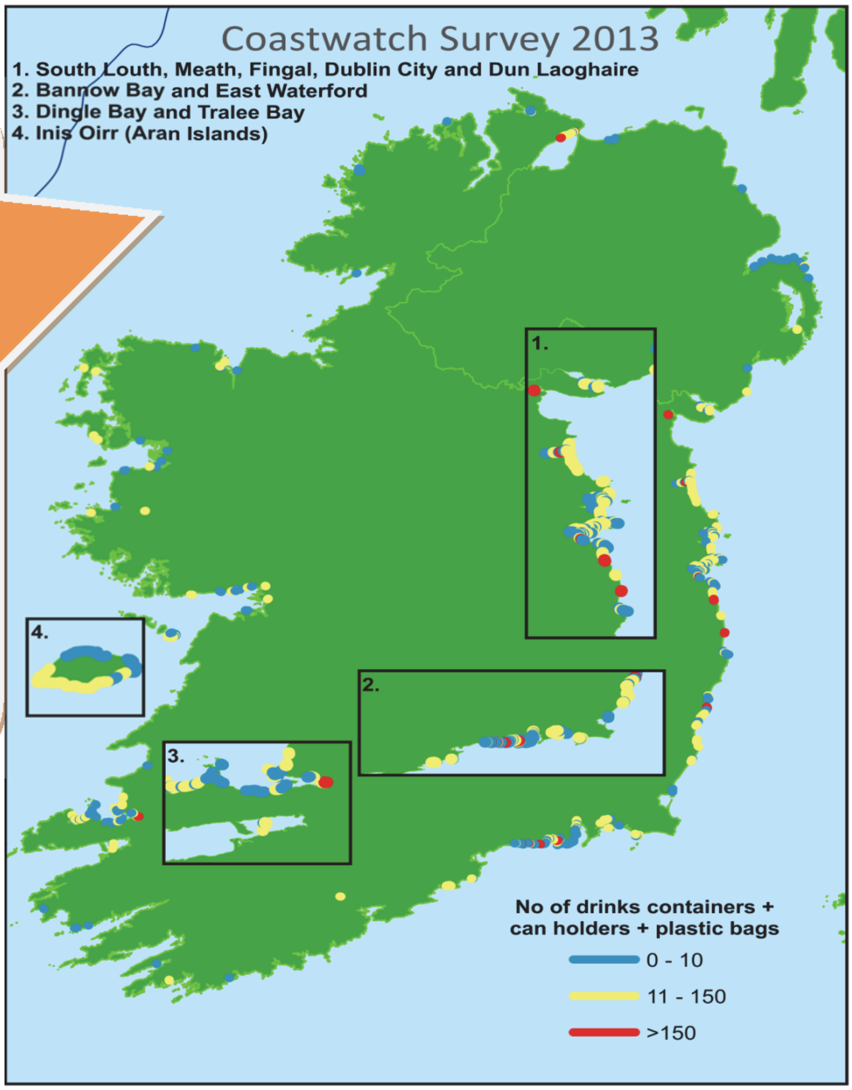




▲ Line chart shows overall numbers of items collected per OSPAR survey per year in the NWW waters (Celtic Seas) in comparison with the North Sea. Map indicates the distribution of the three areas. Pie chart shows composition of litter along the Celtic Seas coastlines (2002-2012). The "other" category includes: rubber, cloth, wood, glass, pottery, medical, faeces and pollutant waste products.

Citizen Science

COASTWATCH volunteers survey coastal sites at low tide, carrying out water quality tests and recording details on biodiversity and marine litter. In Ireland in 2013, over 900 volunteers surveyed more than 300 km of the shoreline. Data from all surveys are combined to create a "jigsaw" of the entire shore line for the given timeframe, e.g. autumn 2013. For further info see coastwatch.org.



Management of Plastic Waste

Coastal litter data can indicate how management measures help to reduce marine pollution.

It is evident from all of the monitoring programs that plastic makes up a major component of the marine litter pollution. Plastic bottles are the most common drinks litter found in Coastwatch surveys, present in about 85% of the sites surveyed. There has been a steady increase in plastic bottle litter, since the survey began. Currently plastic bottles are part of a one way system with no incentive for reuse.

Plastic shopping bags were found in 47% of the survey units. In contrast to the plastic bottles, the trend of plastic bags is decreasing. The plastic bag levy was introduced in Ireland in 2001 as part of the Waste Management (Amendment) Act 2001. This corresponds with a sharp drop in the instances of plastic bags found on the Irish coastline, suggesting a successful response to this management measure.

Microplastics

A growing concern is the abundance of microplastics in the marine environment. These smaller pieces of plastic debris are not visible to the naked eye. Microplastics can derive from the breakdown of larger plastic items by mechanical and chemical erosion, cosmetic products, industrial abrasives and in synthetic fabrics, the fibres of which are flushed into the sewage systems with every clothes wash. Surveyors reported seeing visible patches of micro litter on 17% of the sites surveyed; but the real extent of microplastics in the marine environment is not known. Research is ongoing to address the fate of these, how these plastics are derived from larger pieces of marine debris, and their potential ecological impacts.

▲ Carnivan Beach Wexford.

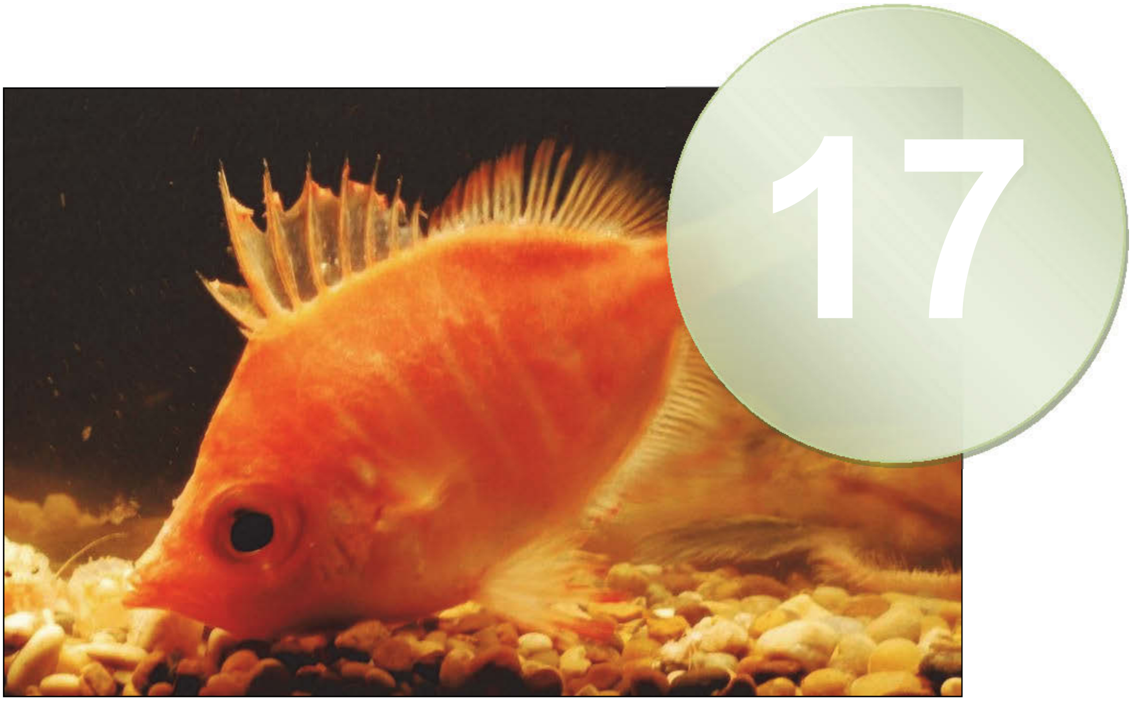
Impacts of Marine Litter on Marine Life

Marine litter causes harm and may kill marine life, primarily through entanglement and ingestion. Sea and water bird species such as gannets, fulmars, gulls, cormorants and razorbills are frequently victims of entanglement with litter as are marine mammals. Ghost fishing, where marine species become entangled in abandoned fishing gear, can result in high mortality.

The effects on the marine organisms of litter ingestion is little understood, including how it affects physical condition, potential effects on survival and reproductive rates and ultimately population level effects. Microplastics ingested by fish may also carry a risk to human health, when ingested particles are passed up the food chain. Plastic contamination in seafood can be high (Murray and Cowie, 2011).

Socio Economic Impacts

Marine litter can bear socio economic costs through the losses of potential income from ecosystem goods and services. This can range from the a reduction in marine tourism due to unsightly beach litter, to the loss of natural resources due to death by entanglement from abandoned fishing nets.



ECOSYSTEM OVERVIEWS

Key Points

The NWW area consists of a large and diverse ocean area. In the NWW Atlas we have used 5 broad ecosystem overviews based on the following subregions: Irish Sea, Celtic Seas, West of Scotland and Rockall, and Widely Distributed and Migratory Stocks and Deepwater.

There has been a strong reduction of fishing mortality on demersal, pelagic and shellfish stocks in all subregions in the last decade.

In the Irish Sea there are still a number of severely depleted stocks e.g. cod, whiting and sole. A significant proportion of the catch of the demersal fleets is discarded.

There has been an overall increase in spawning stock biomass in the last decade, in particular in the Celtic Sea.

Surface waters of the Rockall trough have been steadily warming for some years and are currently at an all-time high. The general and continuing reduction of copepod abundance and recent changes in zooplankton composition throughout the region are causes of concern given the key role that these organisms play in the food web.

Most fishing for widely distributed and migratory stocks is pelagic in nature and there is little or no direct effect on the benthic community.

This section provides a series of five ecosystem overviews that represent the main areas within the NWW RAC area. They are for the Irish Sea (ICES Division VIIa): the Celtic Sea Area (ICES Divisions VIIe-k), the shelf areas to the West of Scotland and Rockall (ICES Divisions VIa and VIb), the pelagic waters to the west of Ireland and Scotland (ICES Divisions VII and VI) and the deepwater areas to the west of Ireland and Scotland (ICES Divisions VII and VI). These summary tables have been sourced from the Marine Institute's annual Stock Book (2014).

Ecosystem description for the Irish Sea

	Physical Features
Bathymetry	For the most part the Irish Sea is shallow semi-enclosed shelf sea with a depth range of between 20m and 100m. A deeper channel running north to south bisects the region. It connects with the Malin Shelf and Atlantic Ocean through the North Channel and the Celtic Sea via the St George's Channel. It reaches a maximum water depth of 315m in the Beaufort's Dyke in the north-central region.
Substrates	In the north and central regions the tidal streams are weakest and sediments are primarily composed of sublittoral muds, deep sea muds and muddy sands. In the higher energy regions in the south, the sediments are dominated by sublittoral course sediment and there is little or no sedimentation (MESH, 2010). A number of sandbanks, including the Kish Bank and Blackwater Bank, run north to south parallel to the Irish east coast (Roche et al., 2007).
Circulation	The Irish Sea receives waters from the weak but persistent flow of the Irish Coastal Current (ICC) which originates from the coast of Brittany (Brown et al., 2003, Fernand et al., 2006) and Atlantic waters through the North Channel. Where these water masses meet at the southwest of the Isle of Man a standing wave and weak currents are generated (Horsburgh et al., 1998).
Fronts	A cyclonic, near-surface gyre is found during the spring and summer in the Western Irish Sea (Simpson, 1971, Hill et al., 1997, Simpson and Hunter, 1974). The tidal Celtic Sea Front is also created with the onset of stratification. It is located across the St. George's Channel and forms the entrance to the Irish Sea (Simpson, 1976). A year-round salinity front also exists in the Liverpool Bay area (Simpson et al., 1990).
Temperature ↗ **Salinity →** (1904-2012)	Seasonal temperatures range from around 7-14°C and monthly SSTs in the early part of 2013 were up to 1°C lower than the 10 year average. Long term time series (off the Isle of Man) indicate an increase in annual SSTs by approximately 0.7°C between 1904 and 2012. No significant long-term salinity trends have been identified at this location (O'Brien et al., 2012). Low salinities, principally due to freshwater inputs are found in Liverpool Bay (Polton et al., 2011, Hopkins and Polton, 2012).

	Biological Features
Phytoplankton Diatom abundance → (1996-2010) Dinoflagellates → (1996-2010)	No significant trends in phytoplankton abundance have been found in time series between 1996 and 2010 (O'Brien et al. 2012), however longer term trends indicate a decline in diatom and dinoflagellate abundance (O'Brien et al. 2012, McGinty et al., 2012). The spring blooms are generally dominated by diatoms with peak abundances in April/May while the abundance of dinoflagellates peaks in September. Microflagellated algae can also contribute significantly to the spring bloom and peak in abundance between April and September (O'Brien et al. 2012).

Zooplankton *Overall Abundance* ↘ *(1958-2010)*	Longterm times series starting in 1958 show a decline in overall zooplankton abundance in the Irish Sea (O'Brien et al. 2013).Three of the five most common herbivorous copepod taxa have declined in biomass/abundance (*Calanus* spp. I–IV, *Acartia* spp. and *Paracalanus* spp. and small copepods <2 mm) between 1960-1999 and 2000-2009. *C. helgolandicus* and *Temora longicornis* have increased. All four species/groups of common carnivorous zooplankton declined in biomass/abundance over the same time period (Euphausiids, Chaetognaths, Hyperiids and Decapods) (McGinty et al., 2012). Jellyfish are increasing in abundance in the Irish Sea (Lynam et al., 2011). The common jellyfish *Aurelia aurita* is the most widespread and abundant species (Doyle et al., 2007, Lynam et al., 2011).
Benthos and reefs	Five biotopes (communities associated with geophysical and hydrographical information) have been identified in the Irish Sea (IOSEA, 2011). The *Brissopsis* assemblage, which includes *Nephrops*, is associated with sublittoral mud in the western basin below 70m. The *Amphiura* community, which includes brittle star, sea urchin and turret shell is found in shallow muds surrounding the *Brissopsis* community. The *Abra* community is found in localized western areas in shallow (5–30m) nearshore muddy sands with rich organic content. The shallow *Venus* community, which has two sub-communities of *Tellina* and *Spisula,* is widely distributed around the coastline and the deep *Venus* community, consisting of urchin and bivalves is strongly associated with course and mixed sediments in moderate depths (40-100 m). The Irish Sea also contains examples of Habitats Directive Annex I reef (The Pieces 'rocky' Reef Complex) and submarine structures made by leaking gases (Croker Carbonate Slabs) (JNCC 2011a, 2011b).
Fish community	The Northern Ireland Groundfish Survey recorded 66 fish species in the Q1 survey and 68 species in the Q4 survey in 2013 (ICES, 2014b). The main commercial species identified in both surveys were cod, haddock, whiting and plaice. The Irish Sea harbours important spawning and nursery grounds for demersal species such as cod, whiting, ling, plaice and sole and pelagic species such as herring (Ellis et al., 2012).
Mammals	Eleven cetacean species have been identified in the Irish Sea between 2000 and 2009 (Berrow et al., 2010). The harbour porpoise, short-beaked common dolphin and common bottlenose dolphin are the most common sightings. Two species of seal are found in the Irish Sea. The grey seal is larger and more abundant than the harbour seal. The largest grey seal populations are found on St.Patrick's Island, Lambay Island and Rockabill Island and Dalkey Island (Co. Dublin) and Wicklow Head (Co. Wicklow) (Ó Cadhla and Strong, 2007). Harbor seal populations have been identified in Carlingford Lough, Lambay Island and Skerries (Co. Dublin), Clogherhead and Dundalk Bay (Co. Louth) and Wexford harbour (Cronin et al., 2004).
Seabirds *Draft OSPAR ECO QO* ↘ *(2004-2012)*	Twenty-six species of seabird have been identified in the Irish Sea region. The most common species found during the breeding season are the Black-legged kittiwake, Northern guillemot and Manx shearwater. Rockabill Island, Ireland's Eye and Lambay Island are considered to be the most important breeding grounds (Mackey et al., 2004, Mackey and Giménez, 2004). The OSPAR draft ECOQO for seabirds in OSPAR region III (Celtic Seas) which includes the Irish Sea, shows a downward trend since early 2000 (ICES 2013b).

Climate change effects on finfish and shellfish stocks	The northwards shift of both cold-water and warm-water zooplankton Calanus out of and into the Irish Sea is expected to impact on the distribution of many species (Richardson, 2008). Cod reductions since the 1990s may be due to a combination of small spawning stock biomass and poor environmental condition (Drinkwater, 2005). Plaice recruitment appears to have a negative relationship with sea surface temperature and effects on herring are not known as there are irregular productivity cycles (ICES, 2013a). It is thought that adult finfish may be tolerant of changes in pH because CO2 levels are variable as a result of activity, but larvae may be negatively affected (Ishimatsu et al., 2008). Changes in precipitation patterns, river discharges and salinity, particularly in coastal areas could also affect inshore species that rely on these areas for spawning or nursery grounds (Reid and Valdés, 2011).

Human pressures and impacts

Fishing effort

(>10m vessels)

↘

Overall fishing mortality

↘

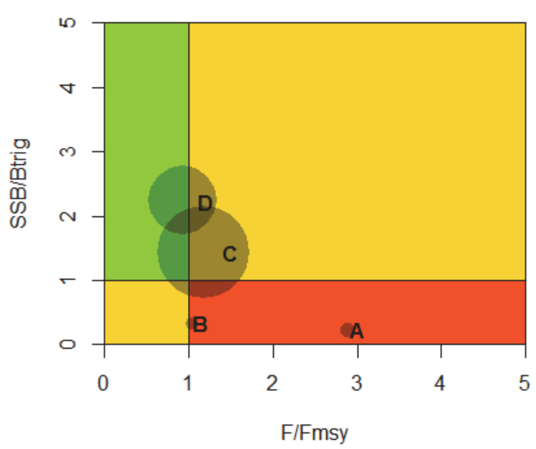
The main human activities in the Irish Sea are:

- Fishing
- Transport
- Dredging for shipping
- Offshore energy

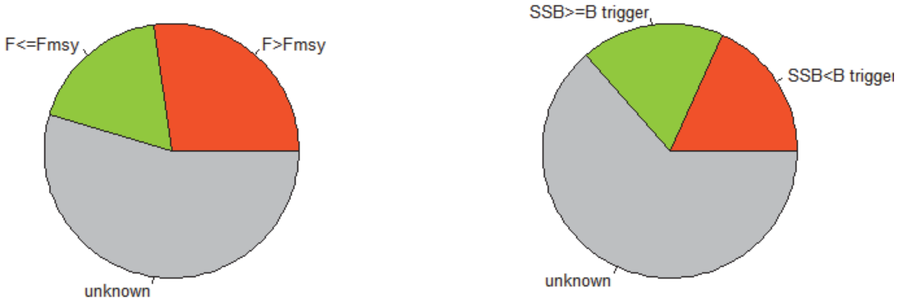
Pressures associated with commercial fisheries are:

- The removal of species
- Seafloor disturbance

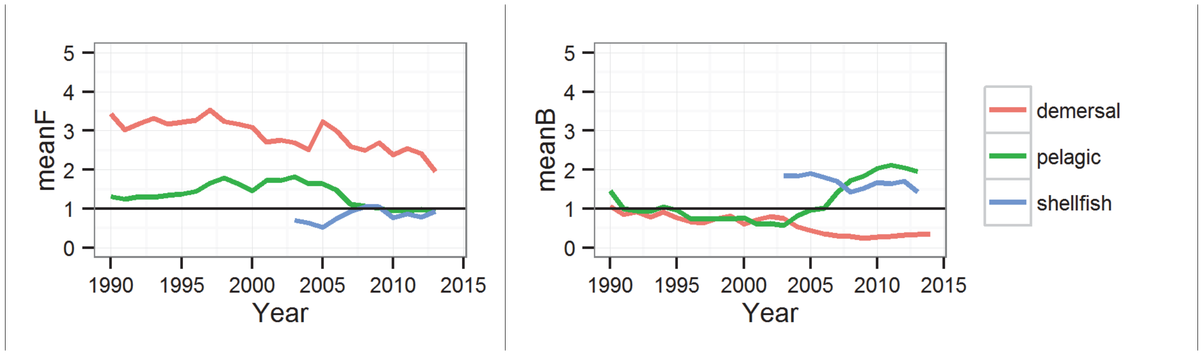
Fishing effort in the Irish Sea has decreased by ca. 40% between 2000 and 2012, the majority of which occurred between 2003 and 2009 (STECF, 2013). Of the 18kt landed from the Irish Sea in 2013, 50% comes from stocks that are fished above F_{MSY}. Two out of the eleven Irish Sea stocks are equal to or above $B_{trigger}$ which corresponds to 75% of the landings, while two are below $B_{trigger}$ namely Irish Sea cod and sole. A high level of discarding is linked to mixed trawl fisheries. Discards of the main commercial demersal stocks by all métiers in the Irish Sea between 2003-2009 ranges from 10% (cod and monkfish) to 100% (whiting). Discarding ratios of100% is common for non-commercial demersal species (Anon., 2011). Towed bottom fishing gears (trawls, dredges, drags, hydraulic devices) impact on seabed species and habitats. Gear type, intensity of trawling, sediment hardness (Foden et al., 2010) and hydrodynamic conditions (Collie et al., 2000, Kaiser et al., 2006) affect a system's ability to recover.



◄ Relative fishing pressure (F/F_{msy}) and biomass (SSB/B_{trig}) for Irish Sea stocks in 2013, with SSB and F related against msy or pa reference points (left panel). This corresponds to 4 out of 11 stocks and 93% of the landings. Stocks in the green region are exploited below F_{msy} and have an SSB that is above $B_{trigger}$. Letter codes for stocks are A Cod VIIa; B Sole VIIa; C *Nephrops* (FU15); D Herring VIIaN. The largest bubble corresponds to 8.7k tons.



▲ Proportion of Irish Sea stocks in 2013 fished at or below F_{msy} (green), above F_{msy} (red) and of unknown status in relation to fishing mortality reference points (left panel) and proportion of Irish Sea stocks with biomass above B trigger (green), below B trigger (red) and of unknown status in relation to biomass reference points (right panel).



▲ Relative fishing mortality (F to F_{msy} ratios) and relative biomass (SSB to $B_{msy\ trigger}$ ratios) of Irish Sea stocks, demersal corresponds to Irish Sea cod and sole, pelagic F corresponds to VIIaN Herring and Shellfish corresponds to *Nephrops* FU14 and FU15 for F to F_{msy} ratios and FU15 for SSB to $B_{msy\ trigger}$ ratios.

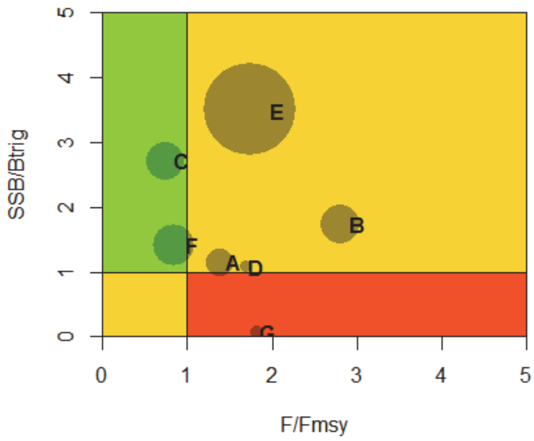
Ecosystem description for the Celtic Sea

	Physical Features
Bathymetry	The Celtic Sea region is an extended shelf south of Ireland, limited to the west by the slope of the Porcupine Seabight and Goban Spur. The topography drops to 80–100 m within 20 km of the coast and extends to the shelf edge (up to 500 km from the coast) as a relatively flat plateau. Coastal areas consist of shallow bays in the south and sites fully exposed to the Northeast Atlantic Ocean in the west (OSPAR, 2000).
Substrates	Deep circalittoral (below low water mark) sand (EUNIS Habitat A5.27) is dominant in the Celtic Sea (MESH, 2010). A deep circalittoral mud habitat (A5.37) is found below 70 m in the Celtic Deep and deep circalittoral coarse sediments (A5.15) are found south of the Waterford and Cork coastlines. The net movement of sediment is in a southwest direction towards the Celtic Sea from the St Georges and Bristol Channels resulting in deposition in the central Celtic Sea region (Nairn et al., 1995).
Circulation	The poleward flowing Shelf Edge Current (SEC) runs from south to north from the Iberian margin to the Norwegian Sea (White & Bowyer, 1997). Thermal stratification and tidal mixing generates the seasonal Irish Coastal Current (ICC) (Horsburgh et al., 1998, Brown et al., 2003, Fernand et al., 2006). This flows westwards from the northern Cornish coast along the south and west of Ireland and northwards towards Malin Head and Scotland.
Fronts	The year-round tidally mixed Irish Shelf Front is located to the south and west of Ireland at 11°W (Huang et al., 1991). The Ushant Front runs between Northern France and the mouth of the English Channel (Le Boyer et al., 2009) and the Celtic Sea Front marks the ecological boundary between the Irish Sea and Celtic Sea (Simpson, 1976).
Temperature ↗ 1959-2012 **salinity**	Mean annual SSTs in the Celtic Sea are around 12.5 to 13°C with a range of 8 to 20°C. SSTs at M5 weather buoy, in 2013, were below 10 year average for the first 6 months rising upto 1°C above average for the latter half of the year. Mean salinity is ca 35 PSU with a range of 32.7 to 35.5 (recorded at MI weather buoys M3 and M5). Longterm datasets from the Malin shelf (1959+) indicate a steady increase in SSTs with mid-2000s values being the highest on record (Beszczynska-Möller, A. and Dye, S. R. (Eds.) 2013).

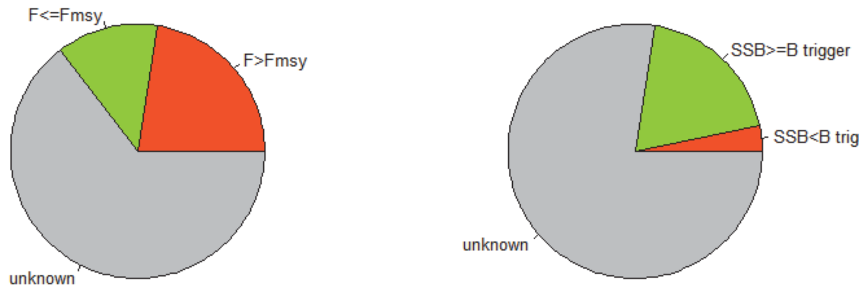
	Biological Features
Phytoplankton *Diatoms* ↗ *Dinoflagellates* ↗ *(1990-2010)*	Diatom and dinoflagellate species abundances are increasing in coastal waters, south and southwest off Ireland based on time series from 1990 to 2010 (O'Brien et al. 2012). Along the south coast diatom abundance generally peaks in July/August and dinoflagellates in October. In the southwest diatom abundance peaks in May and July and dinoflagellates in September (O'Brien et al., 2012). The ICC is thought to be a mechanism that transports blooms around the coast in a clockwise direction (Silke et al., 2005, Fernand et al., 2006).
Zooplankton *Overall Abundance* ↘ *(1958-2010)*	Longterm times series starting in 1958 show a decline in overall zooplankton abundance in the Celtic Sea (O'Brien et al. 2013). Common carnivorous zooplankton Euphausiids, Chaetognaths, Hyperiids, Decapod, Candacia spp., Euchaeta spp. and Corycaeus spp. have all decreased in abundance in the Celtic Sea between 1960-1999 and 2000-2009. Herbivorous copepods Calanus spp. I–IV, Acartia spp., Paracalanus spp., Centropages typicus and Pseudocalanus spp. have also decreased in abundance while the warm-water copepod Calanus helgolandicus has increased (McGinty et al., 2012) and shifted northwards in response to ocean warming (Beaugrand et al., 2002). Gelatinous non-exploited jellyfish species (Cnidaria) have also increased in abundance since 2002 (Licandro et al., 2010).

Benthos and biogenic habitats	Bivalve mollusc (Abra) and brittle star (Amphiura) communities have been identified with the deep circalittoral sand and deep circalittoral mud habitat (Ellis et al. 2002). Dublin Bay prawn *Nephrops norvegicus* and seapen *Virgularia mirabilis* are also associated with his habitat (Doyle et al., 2011). The dominant species associated with the shelf edge are the hermit crab *Pagurus prideaux* and anemone *Actinauge richardii* (Ellis et al., 2002). Two types of reef have been identified: biogenic reef (Belgica Mound Province) comprising *Lophelia pertusa* and *Madrepora oculata* (NPWS, 2006) and rocky reef (Haig Fras) dominated by the jewel anemone *Corynactis viridis* (Rees, 2000).
Fish community LFI → MML → *(1995-2012)*	The most abundant demersal species identified in Irish Groundfish Surveys (2005-2011) were Norway pout, haddock, poor cod and whiting and the pelagic species were blue whiting, mackerel, sprat and horse mackerel (Marine Institute, 2012). The size based fish community indicators "proportion of large fish" and "mean maximum length" are variable but without trends in the Celtic Sea (ICES, 2013e). The Celtic Sea harbours important spawning grounds for demersal species (hake, megrim, anglerfish, cod, whiting and haddock) and pelagic species such as herring, mackerel, horse mackerel, blue whiting, boarfish and sprat.
Mammals *Grey seal pup production* ↗ *(1978-2005)* *Harbour seal pop.* ↗ *(1978-2003)*	Fourteen cetacean species have been identified in the Celtic Sea between 2000 and 2009 (Berrow et al., 2010). The harbour porpoise, short-beaked common dolphin, common bottlenose dolphin and minke whales are the most common sighting. Two species of seal are found in the Celtic Sea. The grey seal is more abundant than the harbour seal. The largest grey seal populations are found at Great Blasket Island (Co. Kerry), Western Calf Island, Low Island and Carbery Island (Co. Cork), Great Saltee Island and Raven Point (Co. Wexford) and an increase in pup production has been noted between 1995 and 2005(Ó Cadhla and Strong, 2007). Harbour seal populations are found in Bantry Bay, Dunmanus Bay, Roaringwater Bay and Kenmare River (Co. Kerry) (Cronin et al., 2007) and have increased in abundance since late seventies.
Seabirds *Draft OSPAR ECO QO* ↘ *(2004-2012)*	Ireland provides essential habitat and prey for internationally important breeding and passage migrant seabirds. Twenty-eight species have been identified in the Celtic Sea region. The most common species found during the breeding season are the Black-legged kittiwake, Northern gannet, Manx shearwater and European storm-petrel. Lady's Island Lake, the Saltee Islands and Keeragh Island (Co. Wexford), Sovereign Island (Co. Cork), Scariff Island, Little Skellig and Skellig Michael and Puffin Island (Co. Kerry) are considered to be the most important breeding and overwintering areas (Mackey and Giménez, 2004). The OSPAR draft ECOQO for seabirds in OSPAR region III (Celtic Seas) shows a downward trend since early 2000 (ICES 2013b).
Climate change effects on finfish and shellfish stocks	The northwards shift of warm-water zooplankton Calanus into the Celtic Sea is expected to impact on the distribution of many species (Richardson, 2008). Lusitanian fish species such as boarfish, sardine, anchovy, bib, poor cod and sea bass have been increasing on the shelf to the north and west of Ireland (Lynam et al., 2010). Boreal species such as cod are at the southern limit of their range in the Northeast Atlantic and it is known that recruitment tends to decrease in warmer waters (ICES, 2013a). It is not yet known whether ocean acidification will affect Celtic Sea finfish and shellfish stocks. Adult finfish may be tolerant of changes in pH because CO2 levels are variable as a result of activity, but larvae may be negatively affected (Ishimatsu et al., 2008). Changes in precipitation patterns, river discharges and salinity, particularly in coastal areas could affect inshore species that rely on these areas for spawning or nursery grounds (Reid and Valdés, 2011).

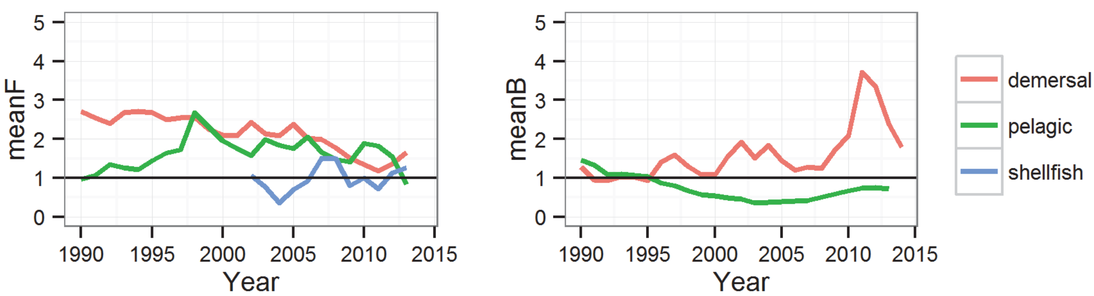
	Human pressures and impacts
Fishing effort (>10m vessels) ↘ *Overall fishing mortality* ↘	The main human activities in the Celtic Sea are: • Fishing • Aquaculture • Transport • Dredging for shipping and aggregates • Offshore energy
	Pressures associated with commercial fisheries are: • The removal of species • Seafloor disturbance About 64% landings in the Celtic Seas region come from stocks which have an analytical assessment. In 2013, four stocks are considered to be fished at or below F_{msy}, seven above and 20 are unknown. A high level of discarding is linked to trawl mixed fisheries. Discards of the main commercial demersal stocks by all métiers in the Celtic Sea between 2003-2009 ranges from 11% (cod) to 73% (plaice). 100% discarding is common for non-commercial demersal species (Anon., 2011). Towed bottom fishing gears (trawls, dredges, drags, hydraulic devices) impact on seabed species and habitats. Gear type, intensity of trawling, sediment hardness (Foden et al., 2010) and hydrodynamic conditions (Collie et al., 2000, Kaiser et al., 2006) affect a system's ability to recover. Gerritsen et al. (2013) estimated that 68% of their study area, in the Irish EEZ of the Celtic Sea, was impacted at least once by trawling during 2011. A considerable portion of the area (46%) was impacted at least twice, and 13% of the area was impacted at least five times. Some of these regions were even impacted ten times or more, although this occurred in <2% of the area. Biota removal could lead to shifts in fish community structures as predator-prey relationships are altered (Jennings and Kaiser, 1998).



◄ Relative fishing pressure (F/F_{msy}) and biomass (SSB/B_{trig}) for Celtic Sea stocks in 2013, with SSB and F related against msy or pa reference points. Stocks in the green region are exploited below F_{msy} and have an SSB that is above $B_{trigger}$. Letter codes for stocks are A Cod VIIe-k; B haddock VIIb-k; C Whiting VIIe-k; D Sole VIIfg; E Hake II, III, IV, VI, VII, VIII; F Herring VIIaS VIIg,j; G Herring VIaS VIIbc. This corresponds to 7 out of 24 stocks and 65 % of the landings. The largest bubble corresponds to 77k tons.



▲ Proportion of Celtic Sea stocks in 2013 fished at or below F_{msy} (green), above F_{msy} (red) and of unknown status in relation to fishing mortality reference points (left panel) and proportion of Celtic Sea stocks with biomass above $B_{msy\ trigger}$ (green), below $B_{msy\ trigger}$ (red) and of unknown status in relation to biomass reference points (right panel).



▲ Relative fishing mortality (F to F_{msy} ratios) of Celtic Sea stocks (left panel), demersal F corresponds to cod 7e-k, haddock 7b-k, northern hake, Celtic Sea sole and whiting 7e-k, pelagic F corresponds to herring VIaS and Celtic Sea herring, shellfish F corresponds to *Nephrops* FU16,17, 19 and 22 and Relative biomass (SSB to $B_{msy\ trigger}$ ratios) of Celtic Sea stocks (right panel), demersal SSB corresponds to cod 7e-k, haddock 7b-k, Celtic Sea sole and whiting 7e-k and pelagic SSB corresponds to herring VIaS and Celtic Sea herring.

Ecosystem Descriptions for the west of Scotland

	Physical Features
Bathymetry	Water depth at the Hebrides and Malin Shelves vary but are generally less than 250 m. The area is bordered to the north by the Wyville-Thompson Ridge at a depth of 500-660m and the entrance to the Rockall Trough at ~1,000m depth and the Porcupine Bank at a depth of ~3,500m to the southwest (New and Smythe-Wright, 2001). To the west of the shelf break is the Rockall Plateau with depths of less than 200m. The area contains several volcanic seamounts: the Rosemary Bank, the Anton Dohrn and Hebrides Seamounts, which have soft sediments on top and rocky slopes (Jacobs, 2006).
Substrates	The north-western shelf area consists primarily of sublittoral muds and sands and infralittoral rock (Ellwood et al., 2011). Canyons, slides, gas seeps and pock marks, iceberg plough marks, exposed rock, carbonate mounds and cold-water reefs are features of the slope (Jacobs, 2006).
Circulation	The shelf circulation is influenced by the poleward flowing European Slope Current. This persists throughout the year north of the Porcupine Bank, but is stronger in the summer (Hill and Mitchelson-Jacob, 1993). This mixes with the Irish and Clyde Sea waters flowing from the North Channel to form the Scottish Coastal Current. As this flows northwards it mixes with less saline, terrestrially influenced coastal waters and more saline shelf and slope waters (Inall and Sherwin, 2006).
Fronts	The Islay Front extends between the Scottish island of Islay and Malin Head in Northern Ireland (Hill and Simpson, 1989, Simpson et al., 1979). It persists year-round at approximately the 50 m isobath.
Temperature ↗ **Salinity** ↗ *(1975-2011)*	Mean annual temperature in the upper 800 m of the Rockall Trough increased from ~9.2°C in 2000 to 10°C in 2006. A decrease of 0.4°C has been noted since then. Salinity has shown a constant increase from the early nineties onwards until its highest values in 2010 (Beszczynska-Möller and Dye 2013).

	Biological Features
Phytoplankton *Diatoms* ↘ *Dinoflagellates* ↘ *(1958-2010)*	Diatom and dinoflagellate abundances have increased since 2004 (O'Brien et al. 2012) but show a decline in the longterm using time series from 1958 (O'Brien et al. 2013). The five common dinoflagellate species found along the Malin Shelf and in the Rockall Trough region are *Ceratium fusus*, *C. furca*, *C. tripos* and *Protoperidinium* spp. and *Dactyliosolen mediterraneus*. The eight diatom species identified in the region are *Thalassionema nitzschioides, Hyalochaete* spp., *Rhizosolenia alata alata*, *Rhizosolenia imbrica shrubsolei*, *Thalassiosira* spp. and *Phaeoceros* spp.
Zooplankton *Overall Abundance* ↘ *(1958-2010)*	Longterm times series starting in 1958 have shown a decline in overall zooplankton abundance (O'Brien et al. 2013). Four carnivorous zooplankton taxa are common to the Malin Shelf and Rockall Trough region. All of these (Euphausiids, Chaetognaths, Hyperiids and *Pleuromamma* spp.) have declined in abundance/biomass between 1960-1999 and 2000-2009. Five out of the six common herbivorous copepods (*Calanus* spp. I–IV, *Acartia* spp., the cold-water *Calanus finmarchicus, Paracalanus* spp. and small copepods <2 mm and *Metridia lucens*) have also decreased in abundance/biomass over the same period. The warm-water *C. helgolandicus* however has increased (McGinty et al., 2012).
Benthos and reef	The shelf megafauna are dominated by echinodermata and arthropoda, with some porifera and cnidaria. The macrofaunal community includes polychaetes, peracarid crustaceans, molluscs and nemertea and the meiofauna are dominated numerically by nematodes and harpacticoid copepods (Davies et al., 2006). Cold-water reef forming *Lophelia pertusa* is found on the north, south and west flanks of the Rockall Bank (Wilson, 1979), the Wyville Thomson Ridge, Lousy Bank and Hatton Bank (Roberts et al., 2003), in the Sea of the Hebrides between the Outer Hebrides and Scottish mainland (Roberts et al., 2005) and George Bligh Bank (Davies et al., 2006).
Fish community *Proportion of large fish* ↘ *Mean maximum length*↘ (1985-2011)	The large fish indicator which measures the proportion of fish >45cm and the mean maximum length (MML) of the fish community have shown strong declines in the early nineties with a further decline for the MML in the last 5 years (ICES, 2013c). The West of Scotland bottom trawl survey records around 100 fish species per year with high numbers of blue whiting, grey gurnard, silvery pout and haddock (ICES, 2014b). Important commercial fisheries exist for haddock, megrim, anglerfish, saithe, ling and herring (ICES, 2014a). Herring have known spawning grounds in the area.
Mammals *Grey seals* → *Harbour seals* ↘ *(2005-2010)*	There are around ten cetacean species recorded in this area including Rockall (Berrow et al., 2010, HWDT, 2014). The harbour porpoise, minke whale and common dolphin are the most common. Current grey and harbour seal estimates for western Scotland are both ~16,000, grey seal populations are stable since 2005, and harbour seals have declined (Thomas, 2011).
Sea Birds *Draft OSPAR ECO QO* ↘ (2004-2012)	The OSPAR draft ECOQO for seabirds in OSPAR region III (Celtic Seas which includes west of Scotland) shows a downward trend since early 2000 (ICES 2013b). Thirty five species of seabirds have been sighted in the north-western shelf region (Mackey et al., 2004). The most common were the common guillemot, razorbill, Atlantic puffin, Northern fulmar, Manx shearwater, northern gannet and gulls.
Climate change effects on finfish and shellfish stocks	Surface waters in western shelf waters and the Rockall Trough have displayed a general warming trend since the mid 1970s. When paired with abundance reductions in the copepod and general zooplankton communities there is cause for concern given the key role they play in marine food webs. A negative impact on recruitment with rising SST has been shown for cod in the west of Scotland (ICES, 2013a). Large grey seal populations are known to feed on this and other species and are likely contribute to total cod mortality. Productivity of the herring stock has reduced since the late 1980s. Again, there is a possible link to increasing SST (ICES, 2013a). Between 1991-2010 the subsurface waters of the Rockall Trough acidified by 0.03 pH units (McGrath et al., 2012). It is thought that adult finfish may be tolerant of changes in pH because CO_2 levels are variable as a result of activity, but larvae may be negatively affected (Ishimatsu et al., 2008). Changes in precipitation patterns,

river discharges and salinity, particularly in coastal areas could also affect inshore species that rely on these areas for spawning or nursery grounds (Reid and Valdés, 2011).

Human pressures and impacts

Fishing effort (>10m vessels) ↘

Overall fishing mortality ↘

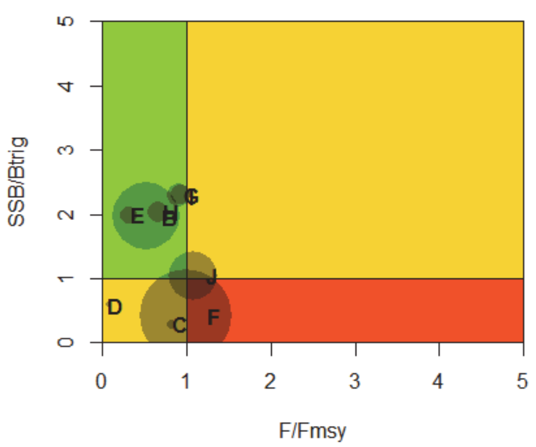
The main human activities in the West of Scotland and Rockall region are:

- Fishing
- Aquaculture
- Transport
- Dredging for shipping
- Offshore energy

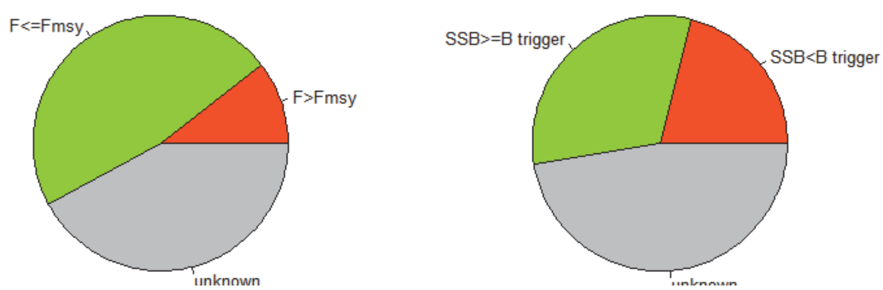
Pressures associated with commercial fisheries are:

- The removal of species
- Seafloor disturbance

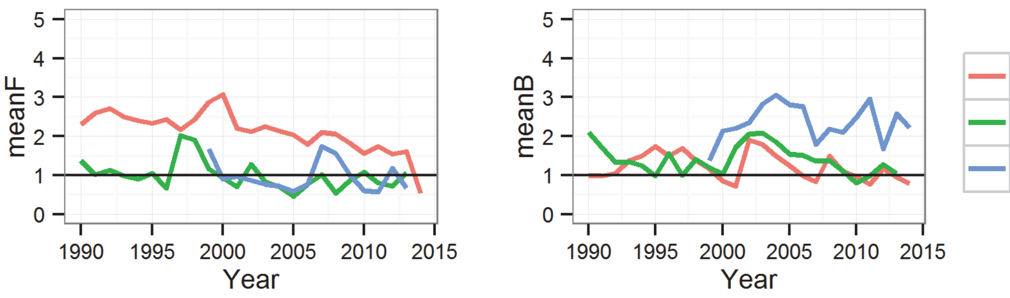
Fishing effort west of Scotland has decreased by more than 40% between peak levels in 2004 and 2012 (STECF, 2013). Of the 194 kt* landed from the area in 2013, 72% comes from stocks that are fished at or below F_{MSY}. Six out of 21 stocks are equal to or above $B_{trigger,}$ while four stocks are below. There are unsustainably high levels of discarding of cod, haddock and whiting (ICES, 2014a).Towed bottom fishing gears (trawls, dredges, drags, hydraulic devices) impact on seabed species and habitats. Gear type, intensity of trawling, sediment hardness (Foden et al., 2010) and hydrodymanic conditions (Collie et al., 2000, Kaiser et al., 2006) affect a system's ability to recover. Due to the presence of vulnerable deep water habitats in the region, large areas on the Rockall and Hatton Banks and in the Rockall region are closed to fishing. New records of VME indicators species have been found in unprotected areas of Rockall bank and the Wyville Thomson Ridge (ICES, 2014c&d).
**includes landings from other areas for some stocks.*



◄ Relative fishing pressure (F/F_{msy}) and biomass (SSB/B_{trig}) for stocks west of Scotland in 2013, which have SSB and F related against reference points (msy where available, otherwise pa). This corresponds to 10 out of 18 stocks and 84 % of the landings. Stocks in the green region are exploited below F_{msy} and have an SSB that is above $B_{trigger}$. The largest bubble corresponds to 80k tons. Letter code for stock: A Cod VIa; B Haddock VIa; C Haddock VIb; D Whiting VIa; E Megrim VIa and IV; F Saithe IV & VI and IIIa; G *Nephrops* (FU11) VIa; H *Nephrops* (FU12) VIa; I *Nephrops* (FU13) VIa; J VIa; Herring VIaN.



▲ Proportion of west of Scotland stocks in 2013 fished at or below F_{msy} (green), above F_{msy} (red) and of unknown status in relation to fishing mortality reference points (left panel) and proportion of west of Scotland stocks with biomass above $B_{trigger}$ (green), below $B_{trigger}$ (red) and of unknown status in relation to biomass reference points.



▲ Relative fishing mortality (F to F_{msy} ratios) of West of Scotland stocks (left panel), demersal F corresponds to VIa cod and whiting, VIb haddock, IVa and VIa megrim and haddock and saithe IIIa, IV,VI; pelagic F corresponds to VIaN herring and shellfish F corresponds to *Nephrops* FU11,FU12 and FU13C and FU13J and relative biomass (SSB to $B_{msy\ trigger}$ ratios) of West of Scotland stocks (right panel), demersal SSB corresponds to VIa cod, haddock and whiting, VIb haddock, IVa and VIa megrim and saithe in IIIa, IV,VI; pelagic SSB corresponds to VIaN herring and shellfish B corresponds to *Nephrops* FU11, FU12 and FU13C.

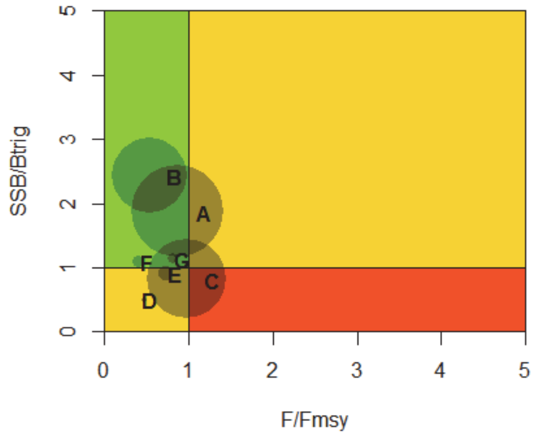
Ecosystem Descriptions for widely distributed Stocks

	Physical Features
Bathymetry	The shelf extends up to 500 km from the west of Ireland. Water depths on the shelf are typically 100-150 m from Biscay to Scotland (Hutchance et al., 2009). The Porcupine Bank to the southwest and Slyne (50-1,000 m water depth), Erris (50-2,000 m water depth) and Donegal Basins (50-200 m water depth) to the west and northwest are found at the shelf edge.
Substrates	The seabed is largely shaped by several glacial periods (iceberg rafting, debris flow) when large volumes of material were eroded from the land and deposited at the shelf edge and over the continental slope. Sediments in VIaS and VIIbcjk are principally muddy sand with gravel, pebbles, cobbles and boulders (Rice, 2004). The modern day sedimentary regime is characterised by sediment reworking and redistribution by near bottom currents and gravity-driven processes (Hartley Anderson, 2005).
Circulation	A number of water masses with distinct temperature and salinity characteristics converge to the west of Ireland (New and Smythe-Wright, 2001). The strength of the subpolar gyre (Hatun et al., 2005) and changes in the mean North Atlantic wind-field (Nolan et al., 2009) influence the variability of the path of warm and saline North Atlantic Current (NAC) from the southwest and Eastern North Atlantic Water (ENAW), which is formed in the Bay of Biscay and carried northwards by the Shelf Edge Current (SEC). A warm high-salinity core of water has been identified in the upper 300 m moving up and down the shelf edge (White and Bowyer, 1997, New and Smythe-Wright, 2001). The seasonal Irish Coastal Current is known to flow around the southwest and west coast of Ireland (McMahon et al., 1995, Horsburgh et al., 1998, Brown et al., 2003, Fernand et al., 2006).
Fronts	The main oceanographic front in the area is the year-round Irish Shelf Front at approximately 11° W around the 150 m contour (Huang et al., 1991). With a total extent of ~500 km it occurs to the south and west of Ireland and creates a separation between saline Atlantic waters and fresher inshore waters.
Temperature and salinity ↗ *(1975-2012)*	Mean annual temperature in the upper 800 m of the Rockall Trough increased from ~9.2°C in 2000 to 10°C in 2006. A decrease of 0.4°C has been noted since then. Salinity has shown a constant increase from the early nineties onwards until its highest values in 2010 (Beszczynska-Möller and Dye 2013).

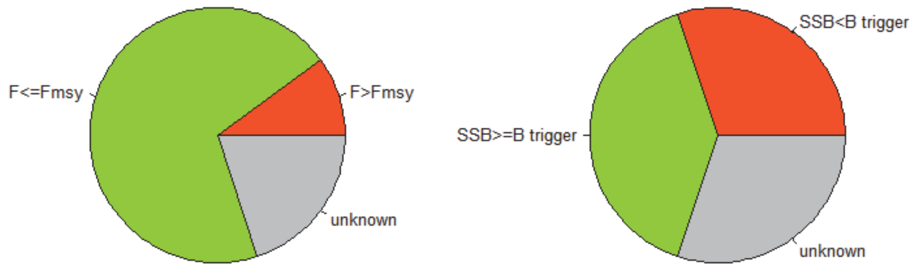
	Biological Features
Phytoplankton *Diatoms* ↘ *Dinoflagellates* ↘ *(1958-2010)*	Diatom and dinoflagellate species abundances in shelf and oceanic waters west of the European shelf show a longterm decline using time series from1958 (O'Brien et al. 2013). All four common dinoflagellate species/groups (*Ceratium fusus*, *C. furca*, *C. tripos* and *Protoperidinium* spp.) found at the shelf edge have declined in abundance/biomass between 1960-1999 and 2000-2009. No species/groups increased over this period. Three out of five diatom species/groups (*Hyalochaete* spp., *Thalassionema nitzschioides* and *Rhizosolenia alata alata*) likewise decreased in abundance/biomass and two species/groups increased (*Thalassiosira* spp. and *Phaeoceros* spp.) (McGinty et al., 2012).
Zooplankton *Overall Abundance* ↘ *(1958-2010)*	Longterm times series starting in 1958 show a decline in overall zooplankton abundance in shelf and oceanic waters west of the European shelf (O'Brien et al. 2013). Seven species/groups of carnivorous zooplankton (Euphausiids, Chaetognaths, Hyperiids, Decapods, *Pleuromamma* spp., *Candacia* spp. and *Corycaeus* spp.) and five species/groups of herbivorous copepods (*Calanus* spp. I–IV, *Acartia* spp., *Paracalanus* spp. and small copepods <2 mm, *Centropages typicus* and *Calanus finmarchicus*) in the shelf edge region have declined in abundance/biomass during the periods 1960-1999 and 2000-2009. One Carnivorous zooplankton group (*Euchaeta* spp.) and one herbivorous copepod species (*C. helgolandicus*) has increased in abundance/biomass during the same periods (McGinty et al., 2012). *Calanus* spp. are used as indicators of increasing SST in the Northeast Atlantic region (Beaugrand et al., 2002).
Fish community Blue whiting ↗ (1981-2013) Mackerel ↗ (1990-2013) Horse Mackerel ↘ *(1982-2013)* Boarfish *(1991-2013)* ↘	Several important pelagic NEA stocks migrate and spawn along the western European slope, namely blue whiting, mackerel, horse mackerel and boarfish. Hydrographic conditions and food supplies in the shelf edge region play an important part in each stage of their life cycle. **Northeastern Atlantic blue whiting** is distributed from the Canary Islands to Spitsbergen along the continental margin. The Porcupine Bank, St. Kilda and Rockall are the main spawning areas (Heino and Godo, 2002). Nursery areas are found along shelf edges from Morocco to northern Norway. Migration patterns from the spawning grounds are thought to be influenced by the strength of the subpolar gyre (Hatun et al, 2009b). Feeding areas include the Faroe/Shetland area, south of Iceland and along the continental shelf edge from the Bay of Biscay to the Barents Sea (Petitgas, 2010). **Northeastern Atlantic mackerel** distribution extends along the Western European Continent from Iberia to Northern Norway (Hughes et. al. 2014). Nursery areas are found adjacent to coastlines (Borja et al., 2002) and the two main recruitment areas are the Porcupine Bank and the south-eastern Bay of Biscay (Bartsch and Coombs, 2004). Adult mackerel migrate along the shelf edge to northern feeding grounds located in the Norwegian Seas and North Sea in late summer/autumn (Petitgas, 2010). **Horse mackerel** is widely distributed along the Western European shelf from West Africa/Cape Verde Islands into the Norwegian Sea. Spawning areas and migration routes generally follow those of mackerel. **Boarfish** is associated with zones of high offshore productivity (Lopes et al., 2006) and distributed from Norway to Senegal at depths from 40-600 m (Blanchard and Vandermeirsch, 2005). Nursery areas are found close to the seabed in the Celtic Sea and shelf sea areas. Post spawning mature boarfish move from the shelf to form dense feeding aggregations on the offshore banks in the Celtic Sea.

Mammals	The most abundant cetaceans in European offshore waters are common, striped and bottlenose dolphins; long-finned pilot whales, fin whales, minke whales, beaked whales and sperm whales (CODA, 2009).
Seabirds *OSPAR ECO QO* ↘ (2004-2012)	Hydrographic conditions and prey availability make the Atlantic margin an area of high seabird diversity. At least 26 species have been identified in this area. Northern fulmar, Northern gannet, Black-legged kittiwake and Manx shearwater are dominant (Mackey et al., 2004). The OSPAR draft ECOQO for seabirds in OSPAR region III (Celtic Seas which includes west of Scotland) shows a downward trend since early 2000 (ICES 2013b).
Climate change effects on finfish and shellfish stocks	Increasing SST and changes in zooplankton community structures are likely to impact on life histories of migratory species (Edwards and Richardson, 2004, Brunel and Boucher, 2007). Large increases in boarfish abundance in the last decade have been attributed to increases in temperature throughout the water column as well as a general absence of predators (Blanchard and Vandermeirsch, 2005). The strength of the subpolar gyre is thought to influence spawning distribution and success of blue whiting (Hatun et al., 2009a, 2009b). Good recruitment may be associated with a weak gyre. Feeding and migration of horse mackerel patterns appear to be closely related to water temperature (Macer, 1977, Lockwood and Johnson, 1977, Eaton, 1983). Timing and the path of the mackerel migration is influenced by temperature (Hughes et al. 2014, Jansen et al. 2012). Water turbulence, shelf upwelling conditions and the atmospheric North Atlantic Oscillation are possible factors affecting juvenile survival and recruitment (Borja et al., 2002).

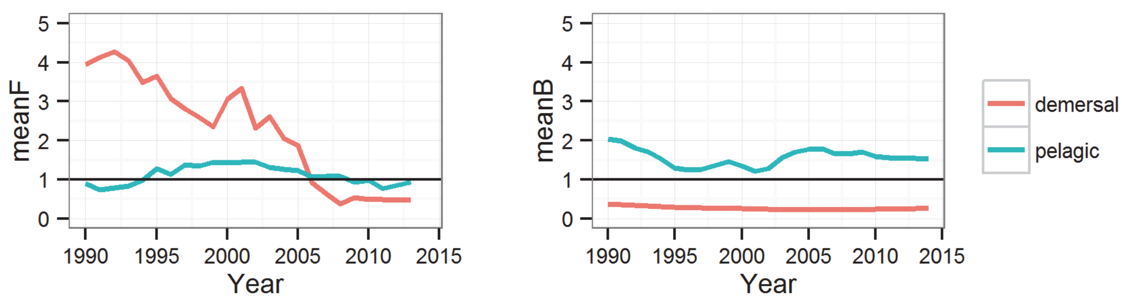
	Human pressures and impacts
Fishing effort → ***Overall fishing mortality*** ↘	The main human activities in the shelf break/slope region are: • Fishing • Transport • Offshore energy Pressures associated with commercial fisheries are: • The removal of species • Bycatch of non-target species Of the 2.5 million tons of the 2013 landings from the widely distributed stocks covered in this section, about 90% comes from stocks that are sustainably fished (i.e. $\leq F_{MSY}$), while around 6% of the landings come from stocks that are overexploited, i.e. western horse mackerel. Both Atlantic tuna stocks and spurdog are below biomass reference points, as is NEA Herring. In pelagic fisheries discarding occurs primarily in the form of slippage when the entire catch is released. Reasons for this are quota limitations and fish that are of sizes that are either illegal or have lower market value (high-grading). Slipping is highly sporadic, which makes it difficult to quantify pelagic discarding and published values of 0.5% to 3% (e.g. mackerel and horse mackerel) are considered underestimates (ICES, 2014a). Small pelagic and mesopelagic species such as sprat, herring as well as Mueller's pearlside, glacial lantern fish and lancet fish are an important food resource for many predatory species, and fisheries for these species need to take consideration of their role in the ecosystem.



◄ Relative fishing pressure (F/F_{msy}) and biomass (SSB/B_{trig}) for widely distributed stocks in 2013, which have SSB and F related against reference points (msy where available, otherwise pa). This corresponds to 7 out of 10 stocks and 90 % of the landings. Stocks in the green region are exploited below F_{msy} and have an SSB that is above MSY B_{trig}. The size of each bubble corresponds to the landings in 2013. The largest bubble corresponds to 930kt. Letter code for stocks: A NEA mackerel; B Blue whiting NEA; C Herring NEA; D Spurdog NEA; E Albacore Tuna; F Bluefin Tuna; G Swordfish.



▲ Proportion of widely distributed stocks in 2013 fished at or below Fmsy (green), above Fmsy (red) and of unknown status in relation to fishing mortality reference points. Proportion of widely distributed stocks with biomass above B trigger (green), below B trigger (red) and of unknown status in relation to biomass reference points.



▲ Relative fishing mortality (F to F_{msy} ratios) of widely distributed stocks, demersal F corresponds to NEA spurdog, pelagic F corresponds to NEA Mackerel, western horse mackerel, NEA blue whiting, and NEA herring (left panel) Relative biomass (SSB to $B_{msy\ trigger}$ ratios) of widely distributed stocks, demersal SSB corresponds to NEA spurdog and relative pelagic SSB corresponds to NEA Mackerel, western horse mackerel, NEA blue whiting and NEA herring (right panel).

Ecosystem Descriptions for Deep Water Stocks

	Physical-Features
Bathymetry	The dominant topographical features of the continental slope region are the northeast to southwest trending Rockall Trough (1,000m at 60°N to 4,000m depth at 53°N) and the Porcupine Seabight (350-3,000m). Both open out onto the Porcupine Abyssal Plain. The Rockall Trough is bounded to the north by the Wyville-Thompson Ridge, the Rockall and Hatton Banks to the west, the Slyne and Erris Basin to the east and the Porcupine Bank and Ridge to the south. The Porcupine Seabight is bordered to the east by the Irish continental shelf, to the west and north by the Porcupine Bank and Ridge and the Goban Spur to the south.
Substrates	The seabed consists of fine sediments (silts/clays) and mixed substrata including sands and gravelly sands on the slopes (MESH Atlantic). Seabed features include carbonate mound systems e.g. the Logachev Mounds, Pelagica Mounds and Porcupine Bank Canyon Mounds, which are made up of layers of foraminifera and coral debris (Kenyon et al., 2003) and volcanic seamounts e.g. Hebrides Terrace and Anton Dohrn Seamount whose topography and current regime provide suitable environmental conditions for a wide diversity of marine species. Carbonate mounds and seamounts have been included on OSPAR's list of threatened and/or declining habitats and species (OSPAR, 2008). Pockmarks, canyons, slides, channels, sandbanks, iceberg scours, contourites and drifts are also found on the continental slope and the abyssal seabed (Sacchetti et al., 2011).
Circulation	Deepwater oceanography to the west of Ireland is complex. Near-surface layers (500-700m) consist of the saline Eastern North Atlantic Water (ENAW), a poleward Shelf Edge Current (SEC) and a branch of the North Atlantic Current (NAC). Intermediate depth water masses (700-2,000m) include the Labrador Sea Water (LSW) (1,600-1,900m) which flows from the west and the dense Norwegian Sea Deep Water (NSDW) which flows southwards over the Wyville-Thomson Ridge. Where the two mix, a salinity maximum known as the North East Atlantic Deep Water (NEADW) is formed at about 2,500m. Below 3,000m, the salinity again decreases, indicating the likely presence of the fresher silicate-rich Antarctic Bottom Water (AABW) (New and Smythe-Wright, 2001).
Temperature and salinity	The deep waters of the NEA <800 m experienced a period of temperature decline in the 1990s, but temperature has increased since 2000. The relatively stable salinity in the first period of measurements (1950 to mid-1970s) was followed by a slow decline through the subsequent 15 years, it has stabilized since 1992 (Beszczynska-Möller, & Dye, 2013).

	Biological Features
Benthos and reef	Deep soft sediments support diverse communities of polychaetes and bivalves. Megabenthos groups include: porifera, cnidarians, echinodermata, crustaceans, branchiopoda and fish (Rice, 2004). Cold water habitat-forming corals *Lophelia pertusa* and *Madrepora oculata* are found in Irish waters at depths ranging from 500-1,200m (Wheeler et al., 2007) and can tolerate temperatures from 4°-13°C and salinities between 32-38.8 (Freiwald et al., 2004). Living at depth in the dark they have no symbiotic algae and rely on a supply of current-transported particulate organic matter and zooplankton for food. Their branching carbonate frames support a diverse community of over 1,300 species (Roberts et al., 2006). Updated distribution of coral findings in the NEA is published annually by ICES (2014c&d).
Fish community	The deepwater slopes to the west of Ireland provide habitat for a rich and diverse fish community. Over 170 fish species have been caught and identified by Irish deepwater trawl surveys (Marine Institute, 2012). The number of species peaks at ca. 1200 to 1600m depth. Grenadiers such as roundnose, spearsnouted and Gunther's are very abundant as are smooth rat tails, Baird's smoothhead, *Lepidion eques* and black scabbard. Roundnose grenadier and black scabbard still support limited deepwater fisheries. Many shark species can be considered true deepwater species as they

occupy large depth and horizontal ranges on the continental slope. Two species, *Centrophorus squamosus* and *Centroscymnus coelolepis* have historically supported commercial fisheries. Many of the other species such as *Centroscymnus crepidater* and *Centroscyllium fabricii* are caught commercially as bycatch. On occasion these are landed but generally they are discarded. Deepwater elasmobranchs, chimaerids and rhinochimaerids, also known as rabbit fish, are widespread throughout the area.

Human pressures and impacts

Fishing effort (>10m vessels) ↘ **2000-2013**

Overall fishing mortality ↘ **2000-2013**

The main human activities in the deepwater region are:

- Fishing
- Transport
- Offshore energy

Pressures associated with deepwater commercial fisheries are:

- The removal of species
- Seafloor disturbance

The status of most deepwater stocks is unknown. Exploitation of these stocks has substantially decreased in recent years due to stringent management measures and increased fuel prices. There has been a reduction in deepwater fishing effort of over 75% in ICES Areas VI and VII from peak levels in 2002 to current levels. Of the 14 deepwater stocks for which Ireland has a quota, four are believed to be depleted, while three stocks are believed to be at or above biomass reference points. Where exploitation rates are known, stocks are currently fished at sustainable levels. The decline in deepwater fishing effort has led to the subsequent reduction in discarding of threatened or vulnerable elasmobranch species. However, their status is still of concern with biomasses below any possible reference points. Due to their late age at maturity and low levels of fecundity, it will take time before these stocks can recover to previous levels.

Biogenic habitat such as those formed by the cold water coral *Lophelia pertusa* occur along the slope, on the offshore banks (Rockall and Hatton), on the mid-Atlantic Ridge and on seamounts supporting rich and diverse faunal assemblages. Deepwater trawling as well as set nets and longlining are known to have negative impacts on these habitats (ICES, 2012d).

▼Hatchet fish (*Argyropelecus olferslii)*

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Please note, all links to relevant websites above were accessed successfully on 31st March 2015.

GLOSSARY

Abundance Index Information obtained from samples or observations and used as a measure of the weight or number of fish which make up a stock.

ACOM Advisory Committee – This ICES group is responsible for compiling and analysing all available fish stock information to compile advice on stock levels and strategies for management.

Acoustic surveys Acoustic surveys use sound waves emitted from a "transducer" to estimate the density of plankton and fish shoals. The survey vessel tows the transducer under water, which is linked to an echo sounder in the vessel which records the shoals of fish as "marks" on a screen or paper trace. The density of these marks is used to calculate total biomass of a stock.

Age The number of years of life completed, here indicated by an Arabic numeral, followed by a plus sign if there is any possibility of ambiguity (age 5, age 5+) **(see http://www.efan.no)**

Annual (or seasonal) Total Mortality Rate The number of fish that die during a year (or season), divided by the initial number. Also called actual mortality rate, coefficient of mortality.

Benthic Anything living on, or in, the sea floor.

BIM An Bord Iascaigh Mhara, The Irish Sea Fisheries Board, charged with responsibility for development of the fishing and aquaculture industries in Ireland. **(see http://www.bim.ie)**

Biomass Measure of the quantity, usually by weight in metric tons (2,205 pounds = 1 metric ton), of a stock at a given time.

Biological reference points Various reference points can been defined for fished stocks. These can be used as a management target or a management trigger (i.e. point where more stringent management action is required) Examples include fishing mortality reference points $F_{0.1}$, F_{max}, F_{med}, F_{pa} and biomass reference points B_{pa} and B_{lim}.

By-catch Refers to discarded catch (see Discards) plus incidental catch not purposely targeted by the fishermen.

CECAF Fisheries Committee for the Eastern Central Atlantic – a committee of FAO (see below) and web page **http://www.fao.org/fi/body/rfb/cecaf/cecaf_home.htm**

CFP / Common Fisheries Policy The instrument of fisheries management within the European community **(see http://europa.eu.int/comm/fisheries/policy_en.htm)**

Collapse A stock is considered to have collapsed when the spawning stock biomass has been below $\mathbf{B}_{lim}$ for three consecutive years.

CPUE /Catch Per Unit of Effort The catch of fish, in numbers or in weight, taken by a defined unit of fishing effort. Also called catch per effort, fishing success, or availability.

Demersal Fish, such as cod, whiting, haddock, sole, plaice, skates and rays, that normally swim in mid-water at or close to the sea floor.

Discard Discards are defined as that part of the catch returned to the sea as a result of economic, legal or other considerations.

Discard rate The percentage (or proportion) of the total catch which is discarded.

Ecosystems are composed of living animals, plants and non living structures that exist together and 'interact' with each other. Ecosystems can be very small (the area around a boulder), they can be medium sized (the area around a coral reef) or they can be very large (the Irish Sea or even the eastern Atlantic).

EEZ Exclusive Economic Zone - The sea area around a nation in which it has special rights over the use of marine resources. It extends up to 200nm offshore.

Elasmobranchs Fish, such as skates, rays, sharks and dogfish, whose skeletons are cartilagenous rather than boney (as in the teleost species such as cod, whiting, plaice and herring).

Emergency Measures Measures adopted by the EU prior to the introduction of cod and hake as part of the recovery plan.

Exploitation pattern The distribution of fishing mortality over the age composition of the fish population determined by the type of fishing gear, area and seasonal distribution of fishing, and the growth and migration of the fish. The pattern can be changed by modifications to fishing gear, for example, increasing mesh or hook size, or by changing the ratio of harvest by gears exploiting the fish (e.g., gill net, trawl, hook and line, etc.).

Exploitation rate The proportion of a population at the beginning of a given time period that is caught during that time period (usually expressed on a yearly basis). For example, if 720,000 fish were caught during the year from a population of 1 million fish alive at the beginning of the year, the annual exploitation rate would be 0.72.

Fishing Effort The total fishing gear in use for a specified period of time. When two or more kinds of gear are used, they must be adjusted to some standard type.

Fishing Mortality Deaths in a fish stock caused by fishing.

Gadoids An important family of food fish, including cod, haddock, rocklings, hake, whiting, blue whiting and ling. Usually characterised by the presence of a barbel on the chin.

Gill nets Static nets suspended in the water column to trap fish by the gills.

Groundfish Species of demersal fish dwelling on, or close to the sea floor, as targeted in the annual groundfish surveys around the Irish coast.

Fleet A physical group of vessels sharing similar characteristics in terms of technical features and/or major activity (e.g. the Irish beam trawler fleet < 300 hp, regardless of which species or species groups they are targeting).

Fishery Group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area (e.g. the Irish flatfish-directed beam trawl fishery in the Irish Sea).

ICES International Council for the Exploration of the Seas –Ireland shares the Total Allowable Catches TACs for many stocks we exploit with our European Union partners. Because of this international dimension many stocks need to be assessed in an international fora such as ICES. **(see: http://www.ices.dk/)**

ICCAT International Commission for the Conservation of Atlantic Tuna – **(see: http://www.iccat.es/)**

ICES Sub-area, Division For the purpose of catch reporting and fisheries management, ICES divides the north-east Atlantic into Sub-areas, which can be subdivided into Divisions, these can be further partitioned into statistical rectangles. Sub-areas are indicated by roman numerals (e.g. VII); Divisions are indicated by roman numerals followed by lowercase letters (e.g. VIIa);

IFREMER France's national marine research agency – **(http://www.ifremer.fr/anglais/)**

Inshore fisheries There are various definitions of inshore fisheries including those fisheries that are conducted within 12 miles of the shore, including demersal, pelagic, shellfish and sea angling fisheries.

MCS Marine Conservation Society

Management Plan is a agreed plan to mange a stock. With defined objectives, implementation measures, review processes and stakeholder agreement and involvement.

Maximum Sustainable Yield / MSY The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions. (For species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others.) Also called maximum equilibrium catch, maximum sustained yield, sustainable catch.

Métier Homogeneous Subdivision of a fishery by vessel type (e.g. the Irish flatfish-directed beam trawl fishery by vessels < 300 hp in the Irish Sea).

MPA / Marine Protected Area A conservation area in the sea usually designated for the protection and maintenance of biological diversity and natural and cultural resources.

Natural Mortality Deaths in a fish stock caused by predation, illness, pollution, old age, etc., but not fishing.

OSPAR The Oslo and Paris Commissions, which have the objective of protecting the Northeast Atlantic against pollution. Member countries range from Finland to Portugal and Iceland.

Pelagic Fish that spend most of their life swimming in the water column, as opposed to resting on the bottom, are known as pelagic species.

Precautionary Approach The precautionary approach should be widely applied to conservation, management and exploitation of living aquatic resources in order to protect them and preserve the aquatic environment. The absence of adequate scientific information should not be used as a reason for postponing or failing to take conservation and management measures.

Quota A portion of a total allowable catch (TAC) allocated to an operating unit, such as a Vessel class or size, or a country.

Rate Of Exploitation The fraction, by number, of the fish in a population at a given time, which is caught and killed by man during the year immediately following. The term may also be applied to separate parts of the stock distinguished by size, sex, etc. Also called fishing coefficient.

Rebuilding Plan (See Recovery Plan)

Recovered A stock is considered to have recovered when the spawning stock biomass has been above $\mathbf{B}_{pa}$ for three consecutive years

Recovery Plan This is a multi-annual plan to recover a seriously depleted stock. The plans generally involve agreed Harvest control Rules, Technical Measures, effort controls and various control and enforcement measures.

Recruitment The amount of fish added to the exploitable stock each year due to growth and/or migration into the fishing area. For example, the number of fish that grow to become vulnerable to the fishing gear in one year would be the recruitment to the fishable population that year. This term is also used in referring to the number of fish from a year class reaching a certain age. For example, all fish reaching their second year would be age 2 recruits.

Recruitment overfishing The rate of fishing above which the recruitment to the exploitable stock becomes significantly reduced. This is characterised by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and generally very low recruitment year after year.

Relative Abundance An estimate of actual or absolute abundance; usually stated as some kind of index; for example, the average catch per tow on a survey.

SACs Special Areas of Conservation, sites designated under the European Community Habitats Directive, to protect internationally important natural habitats and species.

SPAs Special Protection Areas (SPAs) are strictly protected sites classified in accordance with Article 4 of the EC Birds Directive, which came into force in April 1979.They are classified for rare and vulnerable birds, and for regularly occurring migratory species.

Sample A proportion or a segment of a fish stock which is removed for study, and is assumed to be representative of the whole. The greater the effort, in terms of both numbers and magnitude of the samples, the greater the confidence that the information obtained is a true reflection of the status of a stock (level of abundance in terms of numbers or weight, age composition, etc.)

Shellfish Fisheries Those fisheries were the target species are either crustaceans (e.g. *Nephrops*, lobsters, crabs and crayfish) or molluscs (Cephalopods, scallops, oysters etc.).

STECF The Scientific Technical and Economic Committee on Fisheries. Established by the European Commission and comprises fisheries scientists and economists from the member states. The role of STECF is to advise the European Commission on scientific, technical and economic issues related to the management of fisheries resources that are exploited worldwide by members of the European Union.

Stock A "stock" is a population of a species living in a defined geographical area with similar biological parameters (e.g. growth, size at maturity, fecundity etc.) and a shared mortality rate. A thorough understanding of the fisheries biology of any species is needed to define these biological parameters.

SSB / Spawning Stock Biomass The total weight of all sexually mature fish in the population. The size of SSB for a stock depends on abundance of year classes, the exploitation pattern, the rate of growth, fishing and natural mortality rates, the onset of sexual maturity and environmental conditions.

Sustainable yield The number or weight of fish in a stock that can be taken by fishing without reducing the stock biomass from year to year, assuming that environmental conditions remain the same.

TAC / Total Allowable Catch is the total regulated catch from a stock in a given time period, usually a year.

TCM / Technical Conservation Measures These measures take the form of closed areas, increased mesh sizes and gear modifications (such as separator panels) and are aimed at protecting specific stocks, or age-classes within that stock, from overfishing (See also Recovery Plans).

Whitefish Term used to describe demersal species such as cod, plaice, ray etc., as opposed to pelagic or salmonid species.

Year class (or cohort) Fish in a stock born in the same year. For example, the 1987 year class of cod includes all cod born in 1987, which would be age 1 in 1988. Occasionally, a stock produces a very small or very large year class which can be pivotal in determining stock abundance in later years.

Yield-per-recruit The expected lifetime yield-per-fish of a specific age (e.g., per age 2 individual). For a given exploitation pattern, rate of growth, and natural mortality, an expected equilibrium value of Y/R can be calculated for



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MARINE INSTUTUE
Rinville
Oranmore
Co. Galway
Tel: +353 91 287 200
Fax: +353 91 387 201
Email: institute.mail@marine.ie

NORTH WESTERN WATERS
ADVISORY COUNCIL
c /o Bord Iascaigh Mhara Crofton Road
Dun Laoghaire Co. Dublin
Tel: +353 1 214 4100
Fax: +353 1 230 0564
Email: nwwac@bim.ie