The Irish Sea Network's Review of the Irish Sea 2022

The Irish Sea Network members:

Manx Wildlife Trust
Treisht Bea-Feie Vannin

Ymddiriedolaeth Natur Gogledd Cymru
North Wales Wildlife Trust

North West Wildlife Trusts

Scottish Wildlife Trust

Sustainable Water Network
SWAN

Ymddiriedolaeth Natur De a Gorllewin Cymru
Wildlife Trust of South & West Wales

Ulster Wildlife

Funding partners:

Esmée Fairbairn Foundation

John Ellerman Foundation

Protecting **Wildlife** for the Future

PAUL NAYLOR

COVER PHOTO: ALEXANDER MUSTARD/2020VISION

Executive summary

Achieving the sustainable use of the seas is challenging for any given nation when considering their territorial waters. However, realising sustainable use across politically and ecologically complex international waters like the Irish Sea is a challenge that must be overcome to restore the marine environment, tackle climate change, support resilient communities, and develop a thriving economy. Current carbon emissions and high levels of destructive activities are damaging the health of people and planet. Protecting and restoring important marine landscapes, alongside better and more joined-up management of the Irish Sea, will be vital to ensure the long-term health of the marine environment.

The Irish Sea Network is an innovative, new partnership comprising of conservation organisations surrounding the Irish Sea that have come together to improve our collective impact for nature. Established in September 2020, through funding provided by Esmée Fairbairn Foundation and the John Ellerman Foundation, the Network's membership includes representatives from: Manx Wildlife Trust, North Wales Wildlife Trust, the North West Wildlife Trusts, Scottish Wildlife Trust, Sustainable Water Network (Ireland), The Wildlife Trust of South and West Wales and Ulster Wildlife.

This document is designed to be The Irish Sea Network's baseline assessment of the Irish Sea, to be used by decision-makers considering management of marine activities in the Irish Sea.

Key findings:

- The Irish Sea is an important regional sea – ecologically and socio-economically.
- The Irish Sea is managed by six different nations, and whilst there is a common basis of regional cooperation in addressing environmental conflicts and the management of activities occurring in, or impacting upon, the Irish Sea through international legislation, the six nations work in different ways, with differing priorities and therefore differing policies, legislation and targets, making management of the Irish Sea complex.
- The Irish Sea is under significant and increasing pressure from climate change and anthropogenic activities such as fishing, aquaculture, development, shipping, aggregates, military activity, recreational activity and pollution.
- 36% of the Irish Sea is designated as an MPA, however in reality only approximately 5% has any management in place and less than 0.01% is fully protected.
- Ultimately there are significant and increasing pressures on the Irish Sea, and insufficient management measures to protect and maintain the health of the Irish Sea.

This document forms the evidence base for the accompanying document 'The Irish Sea Network's vision and position statements'.

Contents

The Irish Sea Network

1. Introduction

The Irish Sea is ecologically rich and diverse, and supports the people and the coastal communities that surround it. It is one of the smaller UK Regional Seas and is unique in the fact that it is bordered by six different nations: England, Wales, Scotland, the Isle of Man, Northern Ireland and Republic of Ireland; all of which govern their territorial sea area with different policies and legislation. However, the marine environment is interconnected and cannot be managed in sections as there are many common issues that cross national boundaries. For example, the need to manage an ecologically coherent network of Marine Protected Areas, pollution, exploitation and infrastructure development, fishing and, increasingly, the effects of global climate change, all of which affect multiple parts of the Irish Sea simultaneously.

The Irish Sea covers an area of about 58,000km^2, with depths largely ranging from 20–100m, with the exception of the North Channel which runs north to south in the western part of the Irish Sea, between Scotland and Northern Ireland, and reaches depths of 315m. The Irish Sea region extends from the Mull of Kintyre in the north to St George's Channel in the south and includes the Firth of Clyde. The Irish Sea connects to the Atlantic Ocean through the North Channel at the northern end and the Celtic Sea through the St George's Channel at the southern end. For this report, we consider the boundaries to be those from Region 5 (Irish Sea) in the Charting Progress 2 *(**Figure 1**; UKMMASC, 2010)*.

Established in September 2020, through funding provided by **Esmée Fairbairn Foundation** and the **John Ellerman Foundation**, the Irish Sea Network is an innovative, new partnership comprising of representatives from conservation organisations surrounding the Irish Sea that have come together to improve collective impact. Responding to the urgent need for greater collaboration across nations and knowledge sharing, the purpose of the Network is to improve the understanding of marine conservation activities and pressures across the Irish Sea, and to provide a forum for communication and co-operation by members. This report forms a baseline account of the current state of the Irish Sea compiled through the collective knowledge of activities occurring in the region, their impact and the measures being made to counter the pressures placed on the marine environment, provided by Network members.

The Irish Sea Network

***Figure 1:** Irish Sea boundary (Charting Progress 2, 2010)*

2. Ecological Importance

The Irish Sea is incredibly diverse; its geology and geographical location result in a number of different marine and coastal ecosystems that support a huge variety of wildlife.

2.1 Key habitats

There are a number of key habitats across the Irish Sea ***(Figure 2, Figure 3)***. Gravelly and sandy sediments, often moderately mobile, occur extensively across the southern Irish Sea; rocky outcrops on the coastal fringes and in deeper waters off North Wales and in the North Channel, provide shelter for fish, crabs, sponges and sea squirts, as well as a hard substrate for algae, barnacles and limpets to attach to; subtidal mud sediments cover much of the northern Irish Sea, providing a habitat for species such as sea pens, brittlestars and commercially important prawn (also known as Dublin Bay prawn, Norway lobster, langoustine and scampi – *Nephrops norvegicus* hereafter referred to as *Nephrops*). Many areas of the Irish Sea are deep, low to moderate-energy sites where there is little tidal movement (ISCZ, 2011). As a result, the seabed communities within them have the potential to be more diverse and consist of longer-lived species than high-energy areas. They are also subject to little natural disturbance and so are particularly sensitive to human pressures (Tillin and Tyler-Walters, 2013). Although not technically a habitat as such, the summer gyre in the western Irish Sea (a hydrodynamic structure caused by summer-warmed waters rotating around a dome of cold water which sits in the deeper Irish Sea basin) retains nutrients and plankton, providing a food source for marine wildlife, as well as retaining non-mobile larvae in the area (Phelps *et al.*, 2015).

Coastal habitats around the Irish Sea are just as diverse; saltmarsh, seagrass meadows, rocky shores, sand dunes, sandbanks, intertidal mudflats and estuaries act as buffers between land and sea, each providing services in primary production, formation of habitat, nutrient and mineral cycling, larval/gamete supply, natural hazard regulation and carbon sequestration. These in turn provide benefits of food provisioning, fish/wildlife food, climate regulation (see section 3.3), immobilisation of pollutants, clean water, tourism and nature watching and recreation (marine megafauna, angling, diving), health and wellbeing, and education. ***Table 1*** shows a selected number of key habitats around the Irish Sea, their importance, threats and legislative relevance.

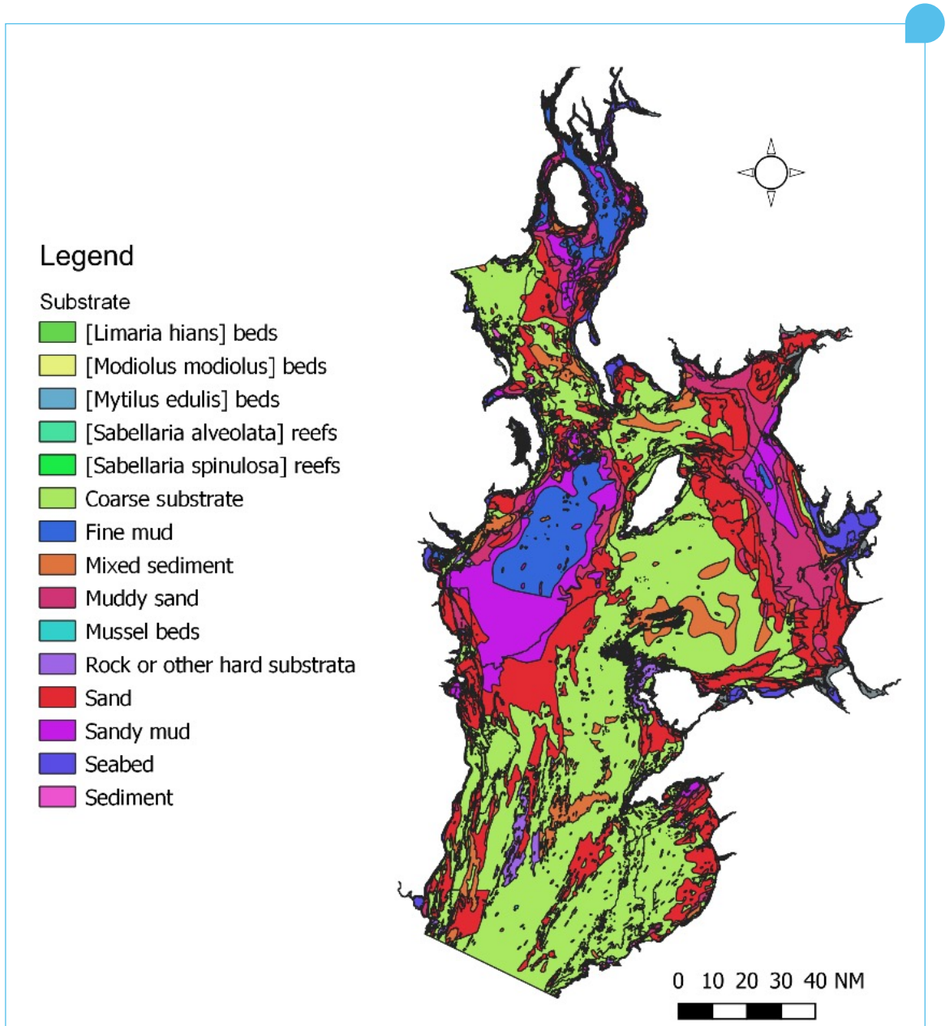


Figure 2: *Map showing the substrate of the Irish Sea, Data from EMODnet*

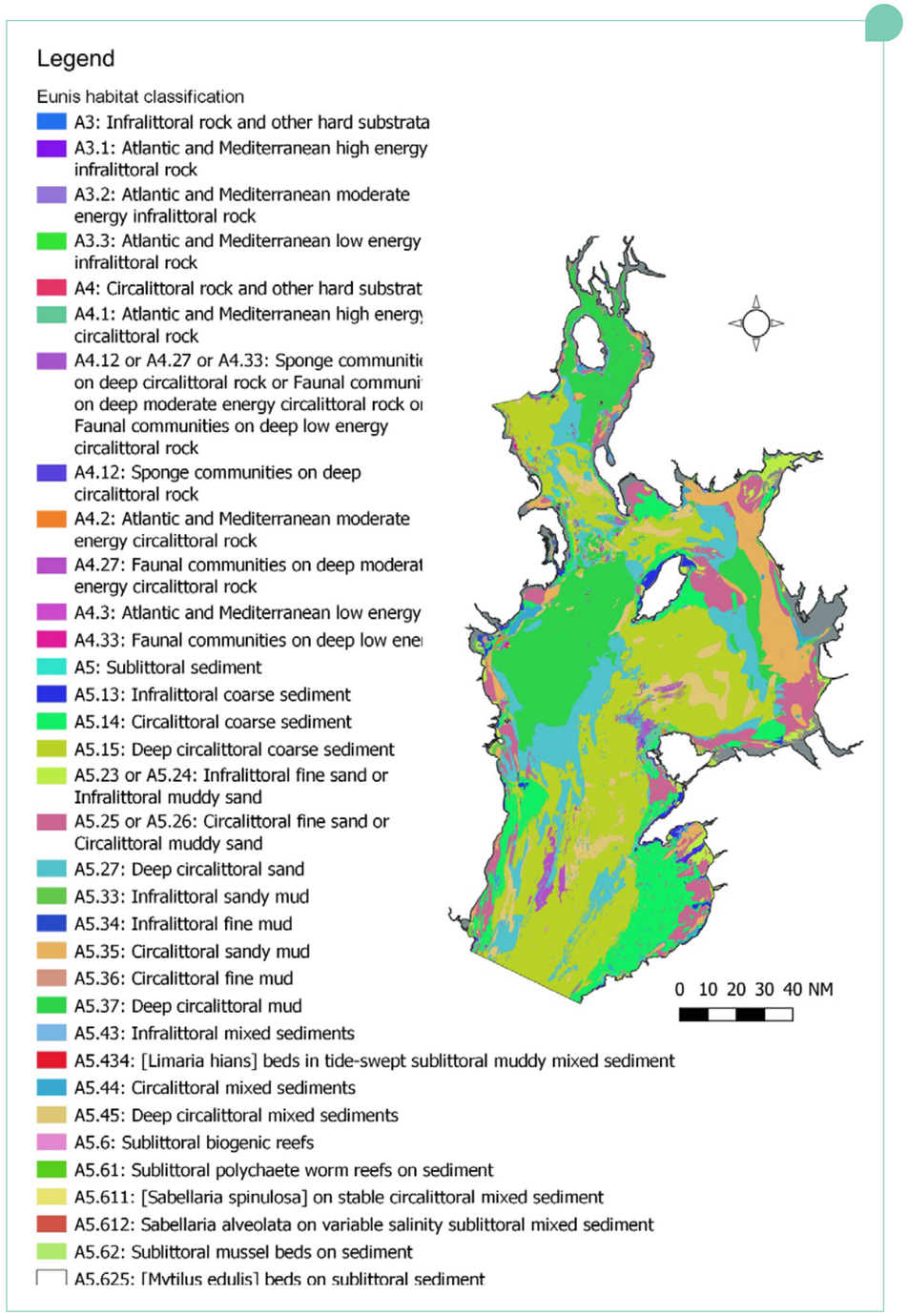


Figure 3: Eunis Habitat Classification. Source: Data form EMODnet

Table 1: Selected key habitats found in the Irish Sea, their importance, threats and legislative importance. BAP = UK List of Priority Species and Habitats (UK BAP); OSPAR = OSPAR List of Threatened and/or Declining Species and Habitats, MCZ = Marine Conservation Zone, MNR = Marine Nature Reserve, SAC = Special Areas of Conservation.

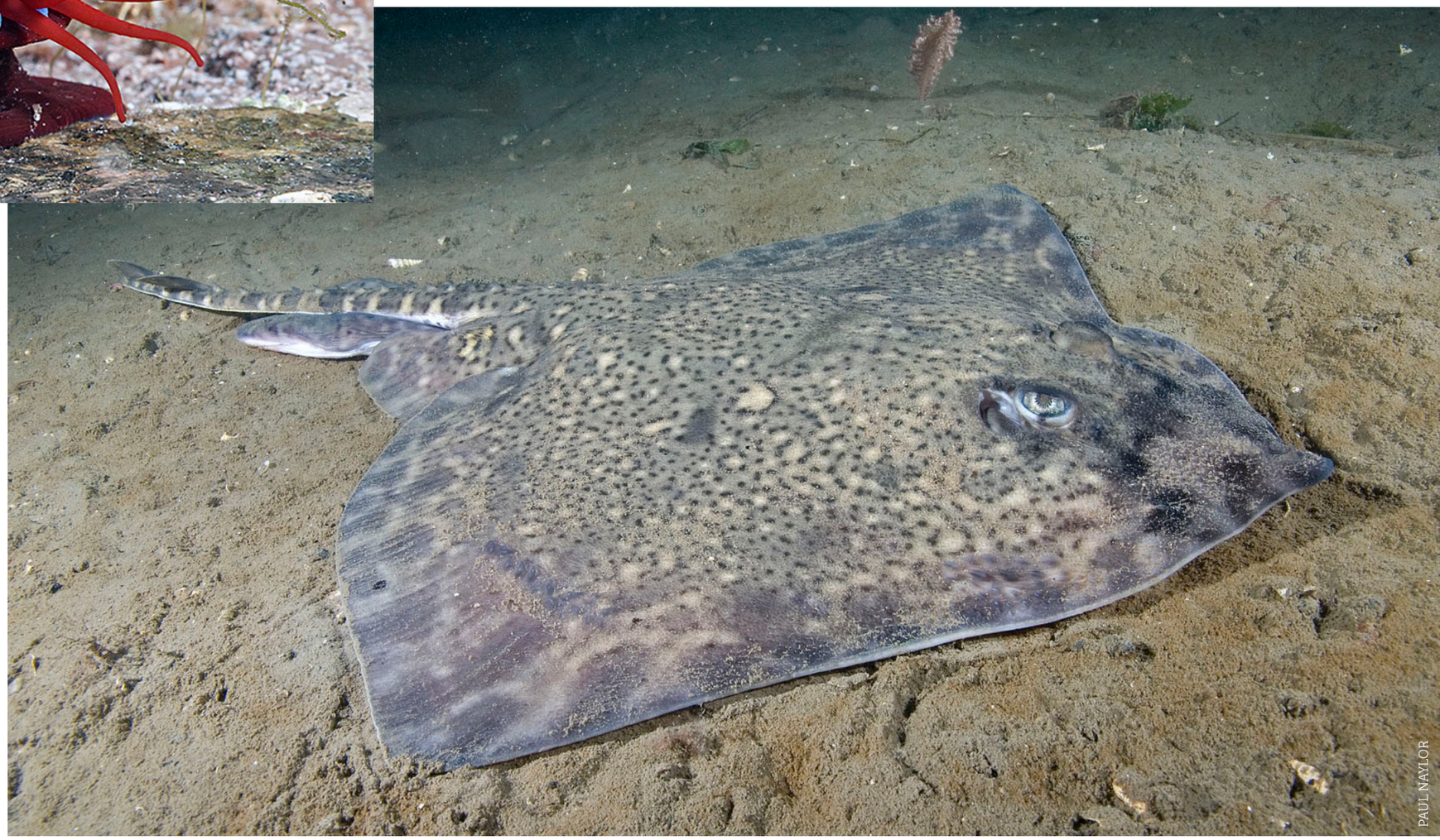
Habitat FOCI (MCZ Features)	Importance	Threats	Relevant policy	Keys areas in the Irish Sea
Honeycomb worm *(Sabellaria alveolata)* reefs	Species diversity	Pollution, coastal development, sea level rise, sedimentation, human disturbance, climate change (cold winters), competition for space with common mussels *(Mytilus edulis)*	BAP	Allonby Bay MCZ, North West England / Extensive areas occur on the Cumbrian coast, North West England / Cardigan Bay, Wales / Glassdrumman, Northern Ireland / Several records off the coast of Dublin and Wicklow, Ireland
Coastal saltmarsh	Blue carbon habitat, coastal stabilisation, nursery habitat, species diversity, water quality	Pollution, coastal development, sea level rise	BAP	Liverpool Bay, North West England / Solway Firth, North West England & Scotland / Small pockets on the Isle of Man
Intertidal mudflats	Species diversity, high biological productivity, important habitat for many protected bird species, nursery habitat	Sea level rise, coastal development, pollution, oil and gas extraction, fishing, human disturbance, non-native species, changes to estuarine dynamics	BAP, OSPAR	Morecambe Bay, North West England / Mersey Estuary, North West England / Strangford Lough / Carlingford Lough / Langness MNR, Isle of Man
Seagrass beds	Blue carbon habitat, coastal stabilisation, nursery habitat, species diversity, water quality	Pollution, coastal development, sea level rise, sedimentation	BAP, OSPAR	Walney Channel and Snab Sands, North West England / Waterfoot, Northern Ireland / Laxey Bay MNR, Ramsey Bay MNR, Langness MNR, Baie ny Carrickey MNR, Isle of Man / Dublin Bay, Ireland / Carlingford Lough
Fragile sponge & anthozoan communities on subtidal rocky habitats	Species diversity	Abrasion from bottom gear fisheries, sedimentation, recreation (diving), climate change, angling	BAP	North and west Anglesey, Wales / The Lleyn peninsula, Wales / Pembrokeshire from Strumble Head in the north to Stackpole in the south, excluding St Brides Bay, Wales / Rathlin Island SAC & MCZ, Maidens SAC, Northern Ireland / South East Coast, Ireland
Mud habitats in deep water	Species diversity, blue carbon habitat	Abrasion from bottom gear fisheries and offshore development	BAP	South Rigg MCZ / Queenie corner MCZ / West of Copeland MCZ / Pisces Reef Complex SAC / Mud Hole / The Great Irish Sea Mudbelt' Off the Dublin and Wicklow, East Coast, Ireland
Sea-pen and burrowing megafauna communities	Species diversity, important habitat for commercially important species, complex habitat, providing deep oxygen penetration	Abrasion from bottom gear fisheries, climate change	OSPAR	South Rigg MCZ / Queenie corner MCZ / West of Copeland MCZ / Carlingford Lough / Strangford Lough / Dundalk Bay, Ireland
Blue Mussel *(Mytilus edulis)* beds	Species diversity, water quality, nursery habitat	Climate change, particularly ocean acidification, pollution	BAP, OSPAR	Strangford Lough SAC & MC / West coast MNR Isle of Man (Intertidal) / Niarbyl Bay MNR, Isle of Man (Intertidal)
Horse mussel *(Modiolus modiolus)* beds	Blue carbon habitat, coastal stabilisation, nursery habitat, species diversity, water quality	Pollution, coastal development, sea level rise	BAP, OSPAR	Ramsey Bay MNR, Isle of Man / Little Ness MNR, Isle of Man / Strangford Lough, Northern Ireland / Off the coasts of Dublin and Wicklow, Ireland
Mäerl beds	Blue carbon, species diversity, queenie sprat settlement preference	Pollution, bottom gear e.g. dredging, ocean acidification	BAP, OSPAR	Little Ness MNR, Isle of Man / Ramsey Bay MNR, Isle of Man / Douglas Bay MNR, Isle of Man / Laxey Bay MNR, Isle of Man / Generally around the Isle of Man / Red Bay SAC, Northern Ireland / Carlingford Lough / Strangford Lough / Isle of Arran, Scotland


MARKTHOMASIMAGES.CO.UK


NIKI CLEAR

2.2 Key species

The Irish Sea is extremely important for marine megafauna, such as whales, dolphins, sharks and rays, turtles and seals because of its rich and productive waters. The basking shark is known to move and migrate through the Irish Sea, feeding on the nutrient-rich stratified waters (Dolton *et al.*, 2020), and it is an important area for critically endangered species of shark and ray like the angel shark *(Squatina squatina)* and flapper skate *(Dipturus intermedius)*. Internationally important numbers of seabirds visit, breed, or overwinter in the Irish Sea – species such as black-legged kittiwakes *(Rissa tridactyla)*, guillemots *(Uria aalge)* and razorbills *(Alca torda)*. Other key species include burrowing megafauna such as ocean quahog *(Arctica islandica)*, burrowing sea urchins (including the sea potato, *Echinocardium cordatum*, and the spiny mudlark, *Brissopsis lyfera*), as well as coastal reef-building worms (*Sabellaria alveolata* and *Sabellaria spinulosa*). ***Table 2*** shows a selected number of key species in the Irish Sea, their use, key threats and protection status.


PAUL NAYLOR

The Irish Sea Network

Table 2: Selected key species in the Irish Sea, use of the Irish Sea, key threats and protection status. W&CA 1981 = Wildlife and Countryside Act 198; UKP-2010BF, 2012 = UK Post-2010 Biodiversity Framework, 2012; OSPAR LTDSH = OSPAR List of Threatened and/or Declining Species and Habitats

Species	Essential Habitat	Known use of the Irish Sea	Key threats	Wider protection/status		Scotland	England	Wales	Northern Ireland	Isle of Man	Republic of Ireland
Basking Shark ***(Cetohinus maximus)***	Plankton rich waters for feeding.	Possible migratory movements, (although some evidence to suggest they spend all year round in the Irish Sea[1]), feeding,	Entanglement/bycatch in fisheries, pollution, reduced prey availability.	UNCLOS Annex I – Highly Migratory Species and Article 64; IUCN Red List as Endangered; OSPAR LTDSH.		Nature Conservation (Scotland) Act 2004.	Schedule 5, W&CA 1981.	Schedule 5, W&CA 1981.	Wildlife (Northern Ireland) Order 1985.	Manx Wildlife Act 1990.	Added to Wildlife act 2022.
Leatherback turtle ***(Dermochelys coriacea)***	Open waters.	Feeding on rich swarms of jellyfish.	Entanglement/bycatch in fisheries, pollution, reduced prey availability.	IUCN Red List as Vulnerable.		Conservation (Natural Habitats, &c.) Regulations 1994; Priority Species under the UKP-2010BF, 2012.	Schedule 5, W&CA 1981; Priority Species under the UKP-2010BF, 2012.	Schedule 5, W&CA 1981; Priority Species under the UKP-2010BF, 2012.	The Conservation (Natural Habitats etc.) Regulations (Northern Ireland),1995; Priority Species under the UKP-2010BF, 2012.	Manx Wildlife Act 1990.	
Smelt ***(Osmerus eperlanus)***	Estuaries.	Spawning, nursery and foraging grounds	River and estuarine pollution, dredging and habitat damage to spawning grounds, barriers to migration.			W&CA 1981 (as amended); Priority Species under the UKP-2010BF, 2012	Marine and Coastal Access Act (2009).	Marine and Coastal Access Act (2009); Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.		
Ocean quahog ***(Arctica islandica)***	Sandy and muddy sediments, between 10 and 280m depth.	Burrowing in sediment, feeding, reproducing. The north-east corner of South Rigg MCZ is home to one of only two known breeding populations of the ocean quahog in the Irish Sea.	Bottom contact fisheries, habitat destruction.	OSPAR LTDSH.		Marine (Scotland) Act, 2010.	Priority Species under the UKP-2010BF, 2012.	Marine and Coastal Access Act (2009).	Marine Act (Northern Ireland) 2013.	Manx Wildlife Act 1990.	
Harbour porpoise ***(Phocoena phocoena)***	Open waters.	Feeding, breeding	Entanglement/bycatch in fisheries, pollution, reduced prey availability, noise pollution.	CITES Appendix II; IUCN Red List as Least Concern; OSPAR LTDSH.		W&CA 1981 (as amended); Priority Species under the UKP-2010BF, 2012.	Marine and Coastal Access Act (2009).	W&CA 1981.	Conservation (Natural Habitats, etc.) Regulations (Northern Ireland) 1996.	Manx Wildlife Act 1990.	Wildlife Act, Annex II of the EU Habitats Directive.
Angel shark ***(Squatina squatina)***	Continental shelves down to 200m depth, also found in estuaries and brackish waters, sandy sediment.		Overfishing, bottom contact fisheries, habitat destruction.	IUCN Red List as Critically Endangered; Convention on Migratory Species (CMS) 2019; OSPAR LTDSH.		W&CA 1981 (as amended); Sharks, Skates and Rays (Prohibition of Fishing, Trans-shipment and Landing) (Scotland) Order 2012; Priority Species under the UKP-2010BF, 2012.	Marine and Coastal Access Act (2009).	W&CA 1981 schedules 1, 5 and 8; Priority Species under the UKP-2010BF, 2012.	Wildlife (Northern Ireland) Order 1985; Priority Species under the UKP-2010BF, 2012.		
Common skate ***(Dipturus batis)***	Sandy or muddy seabeds, down to depths of 600m.	Feeding, breeding. Once common now only found in Celtic sea and North West Scotland.	Bottom contact fisheries, habitat destruction.	IUCN Red list as Critically Endangered; OSPAR LTDSH.		Marine (Scotland) Act, 2010; Sharks, Skates and Rays (Prohibition of Fishing, Trans-shipment and Landing) (Scotland) Order 2012; Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.	The Wildlife (Northern Ireland) Order 1985 (as amended); Wildlife and Natural Environment Act (Northern Ireland) 2011; Priority Species under the UKP-2010 BF, 2012.		
Common seal ***(Phoca vitulina)***	Sheltered shores and estuaries, where they haul out on sandbanks and beaches.	Breeding, feeding, resting.	Entanglement/bycatch in fisheries, pollution, reduced prey availability.	IUCN Red list as Least Concern.		Conservation of Seals Act, 1970; Priority Species under the UKP-2010BF, 2012.	Conservation of Seals Act, 1970; Priority Species under the UKP-2010BF, 2012.	Conservation of Seals Act, 1970; Priority Species under the UKP-2010BF, 2012.	Wildlife (Northern Ireland) Order, 1985; Priority Species under the UKP-2010BF, 2012.	Manx Wildlife Act 1990.	Wildlife Act, and is listed under Annex II of the EU Habitats Directive.
Tall sea pen ***(Funiculina quadrangularis)***	Ranging from muddy sands to fine, clay-dominated muds depth 20m to 2000m.	Patchy distribution, on the North West coast of Scotland and Ireland. Provide habitat for other species.	Bottom contact fisheries, habitat destruction, deoxygenation caused by pollution.			Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.		
Native Oysters ***(Ostrea edulis)***	Sheltered, shallow coastal water and estuaries, tend to be muddy.	Historically abundant.	Overfishing, pollution, disease, invasive species, habitat loss.	OSPAR LTDSH.		Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012; Marine and Coastal Access Act (2009).	Priority Species under the UKP-2010BF, 2012.	Priority Species under the UKP-2010BF, 2012.		
Bass ***(Dicentrarchus labrax)***	Inshore waters.	Nursery ground around the Irish Sea.	Nursery ground around the Irish Sea.						Strict measures since 2016 for anglers https://www.gov.im/categories/leisure-and-entertainment/recreational-fishing/		
Manx Shearwater ***(Puffinus puffinus)***	Coastal cliffs with burrows.	Around the Calf of Man and IOM.	Overfishing, habitat destruction.			W&CA 1981 (as amended).	W&CA 1981.	W&CA 1981.	The Wildlife (Northern Ireland) Order 1985.	Manx Wildlife ACT 1990; Amber listed on Birds of Conservation Concern 2015 IOM.	Amber listed on Birds of Conservation Concern 2020-2026.

[1] New evidence suggests not all are migratory – Irish Sea is a coastal hotspot for this oceanic animal that can spend all year round here (Johnston, 2021)

2.3 Connectivity

The marine environment is interconnected, which has implications for management given that activities occurring in one part of the Irish Sea will affect species and processes in other parts. Case studies 1, 2 and 3 provide examples of the connectivity of the species in the Irish sea.

➤ CASE STUDY 1: Manx shearwater *(Puffinus puffinus)* (Dean *et al.*, 2015)

Seabirds are long-lived, widespread, upper-trophic marine organisms with slow population growth. They are potentially vulnerable to a wide range of impacts at sea, including pollution, incidental mortality in fisheries, incidental mortality and habitat loss associated with marine developments, changes in prey resources as a result of changes in fishery management, oceanic conditions and climate change. Seabirds therefore function as important indicators of ocean health. Manx shearwater are a pelagic forager, predominantly of small clupeids, and the majority of their breeding is restricted to a small number of colonies around the UK and Ireland.

GPS tracking data, that was collected simultaneously at four breeding colonies (Copeland, Lundy, Rum, Skomer), revealed the interconnectivity of the Irish Sea. In addition to local foraging, birds from all four colonies sometimes travelled large distances to forage within a single relatively restricted area. This combined pattern may be driven by density-dependent competition relatively locally, with high overlap and resource sharing at a distance, facilitated by a dual foraging strategy of mixing short and long trips. The key shared area was located near to the tidal Irish Sea Front, and the stratified waters of the western Irish Sea to its north and west caused by the Irish Sea gyre system, which are characterised by high productivity. This area is probably of key importance to birds breeding at colonies across the species' core breeding range, highlighting the potential connectedness, and therefore vulnerability, of a pelagic species via a single foraging location, despite apparent segregation more locally around the breeding colonies.

The Irish Sea Network

➤ CASE STUDY 1: Manx shearwater *(Puffinus puffinus)* (Dean *et al.*, 2015)

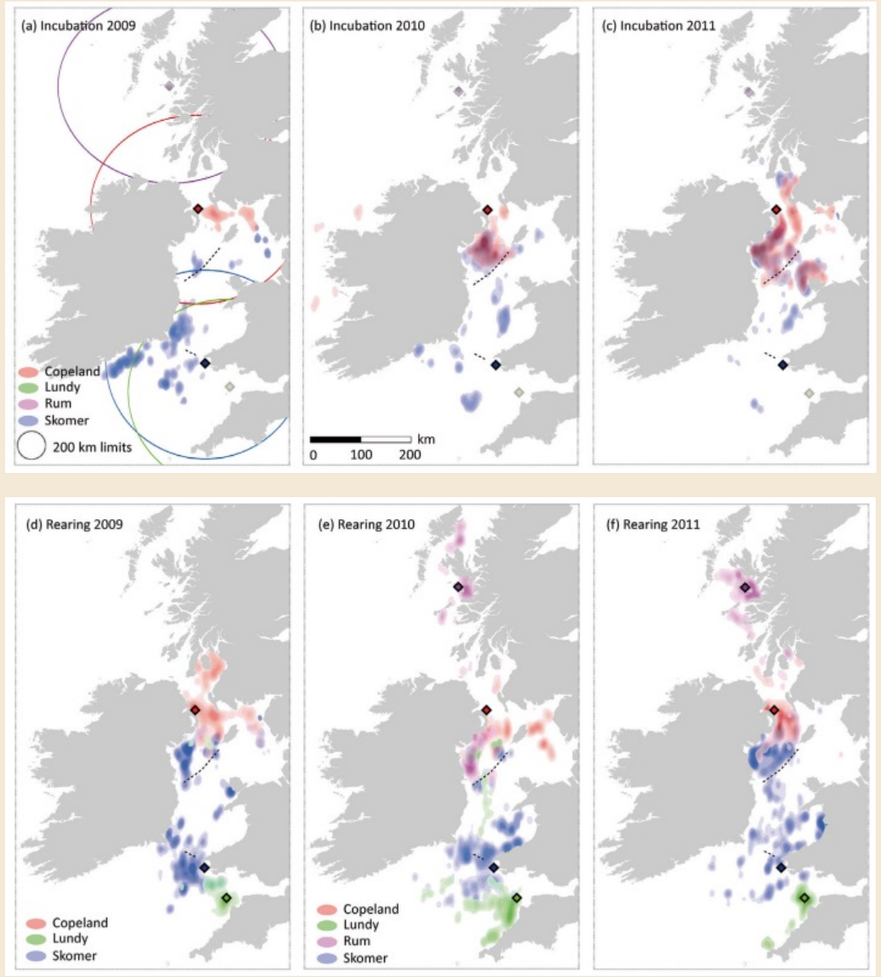


Figure 1. (a–f) Foraging density maps calculated for incubation and chick-rearing in each year. Kernel densities were calculated using those locations classified as foraging by the filtering process. Distributions for each colony: Rum (purple), Copeland (red), Skomer (blue) and Lundy (green) are shaded from low density (lightest colour) to high density (darkest colour) and are translucent to show overlap between colonies. The approximate positions of the Irish Sea Front (curved dotted line) and Celtic Sea Front (dotted straight line) are shown. The colonies are shown by a diamond of the same colour as the kernels, and 200km limits (threshold between short and long trips) around each colony are shown on panel (a), matching the colour of their origin colony. Published with permisson.

CASE STUDY 2: Common cockle *(Cerastoderma edule)* (Coscia *et al.*, 2012; Coscia *et al.*, 2020)

The common cockle has both ecological and commercial importance, providing an important food source for wading birds in addition to employment for coastal communities. It can live for up to ten years and is characterized by high fecundity and high dispersal potential due to a pelagic larval phase which lasts for approximately three to five weeks following spawning from May to August.

Populations of cockles in the Irish Sea have been under pressure for at least two decades, with mass mortality events and declines due to overexploitation leading to strict management of most beds across the UK. Coscia et al., (2020) identified patterns of population structure of the common cockle between seven locations off the coasts of Ireland (Bannow Bay and Flaxfort Strand) and Britain (Burry Inlet, Gann Estuary, Dyfi Estuary, Red Wharf Bay and Dee Estuary). On the Welsh coast, the Burry Inlet appears genetically isolated while samples collected from the coast of Pembrokeshire show evidence of connectivity between Britain and Ireland. Larval transport is controlled by density-driven currents (or lack of) along frontal boundaries that develop due to thermal stratification during summer months. For example, the Celtic Sea front may facilitate connectivity of cockle populations from South Wales across to Ireland, but also restrict transport across the front between the Celtic and Irish seas.

The connectivity of the common cockle across the Irish Sea has implications for fishery management and how fisheries management can be reconciled with conservation and other activities.

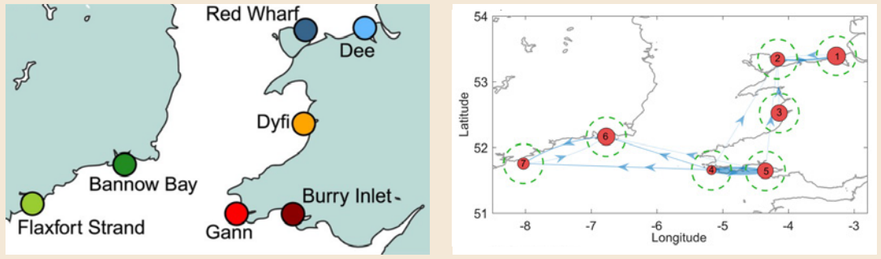


Figure 1: (left) sampling locations; (right) Simulated connectivity between the seven sampled cockle populations. Published with permission

CASE STUDY 3: Sea bass *(Dicentrarchus labrax)* (O'Neil, 2017)

The European sea bass *(Dicentrarchus labrax)* can be found distributed along all coasts of Ireland in addition to most waters of the north-east Atlantic. In recent years, stocks have been declining across Europe and today there are concerns regarding the level of spawning stock biomass and the effects of consecutive years of poor recruitment.

Studies suggest that putative spawning locations along the south-eastern Irish coast and in offshore locations in the Celtic Sea may act as sources of larvae for localities such as south Co. Kerry which is up to 200km away, but could also contribute towards recruitment of sea bass in Northern Ireland and south-western Scotland, thus potentially impacting on sea bass recruitment regionally, nationally and internationally.

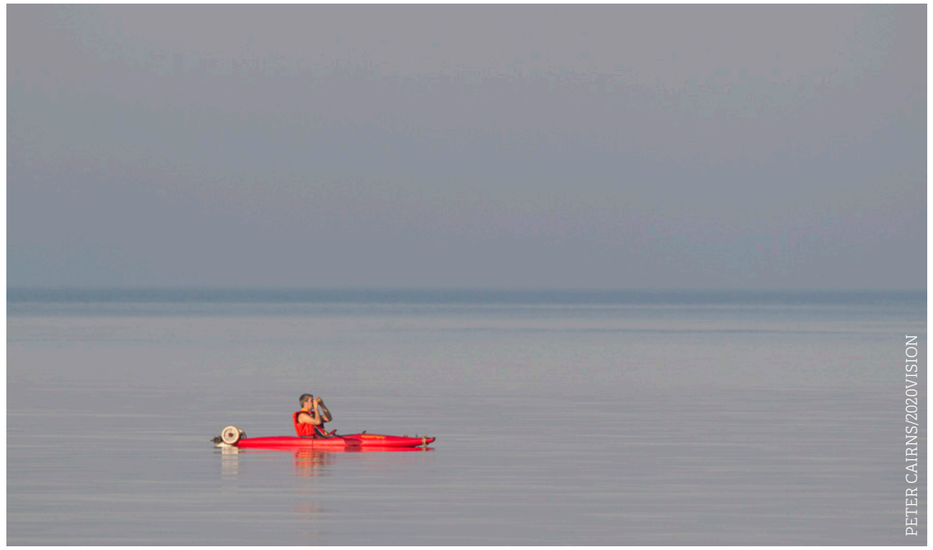
Moreover, genetic information supports the contention that sea bass from inshore Irish waters, from offshore waters in the Celtic Sea and from the North Sea may be part of the same panmictic population. Evidence suggests that sea bass occurring in Irish waters as being an integral part of the larger trans-Celtic Sea population. As a consequence, the sustainable management and conservation of the species occurring in Irish waters must be undertaken on a basis which is international, as well as local – close cooperation between Ireland and the UK is required to manage species sustainably in accordance with ICES advice.

3. Socio-economic importance

In addition to its ecological importance, the Irish Sea is important for the economy, society and human well-being. The Irish Sea area has an estimated population of 15 million and a combined GDP of £430 billion (IRC, 2019). The benefits of a healthy Irish Sea extend beyond coastal communities, with the marine environment providing a whole host of goods and services for the wider population – with both direct and indirect benefits from maintaining the ecosystem in a good condition.

Goods and services include food provisioning, fish/wildlife food, climate regulation, immobilisation of pollutants, clean water, tourism and nature watching and recreation, health and wellbeing, and education. Economic valuation can include easily quantifiable aspects (market goods and services), such as income from fishing or tourism, while others (non-market goods and services) are more difficult to quantify, such as carbon sequestration, recreational use or wellbeing benefits, though they can still be given an indicative monetary value. External pressures (e.g. climate change) can negatively affect the value of goods and services, while good management practices can increase them because the goods and services provided rely on a healthy and intact ecosystem.

Statistics on socio-economic importance of the Irish Sea region as a whole are hard to deduce because of the complexity of management, however an indicative figure for its economic significance can be seen from a recent report which valued the combined ecosystem goods and services of the Irish and Celtic Sea at £2.72 billion to Irish and Welsh coastal communities alone – this figure highlights it's significance even though it does not provide a full insight into the entirety of the Irish Sea and its surrounding nations.



PETER CAIRNS/2020VISION

3.1 Tourism and recreation

Statistics on tourism and recreation are derived from a range of studies focussing on one or more of the nations around the Irish Sea.

The Irish and Celtic Sea's provide an estimated £2.72 billion to Irish and Welsh coastal communities through beneficial ecosystem goods and services. Of this value, 43% comes from tourism (BLUEFISH, 2021). Although Irish Sea specific coastal tourism and recreation statistics are hard to obtain, the importance of coastal recreation and tourism is important for all nations.

On the Isle of Man, the number of visitors during 2018 was 308,263 and the estimated total expenditure by visitors was £132.8 million. The rugged coastline and unspoilt beaches are very popular for outdoor and water sports with activities including kayaking, sea and river fishing, sailing, "coasteering", windsurfing, mountain biking, diving and wildlife watching (IOM, GOV).

Tourism related to beautiful landscapes and coastline is a fundamental part of economic prosperity and job creation in Wales and, in 2009, the industry was worth £6.2 billion to the economy or 13.3% of GDP (Deloitte and Oxford Economics, 2010 cited in Simpson, 2013). In 2011, Wales received 0.9 million international visitors and between 2006 and 2009, 37% of international holiday tourists to Wales visited the coast with 31% participating in sports activities (Visit Britain, 2019). Activities in Wales include water sports such as surfing, diving and climbing as well as fishing and boating.

In 2019 there were an estimated 5.3 million overnight trips in Northern Ireland (including both external visitors and local residents taking domestic trips) with an estimated associated expenditure of £1.0 billion (Nisra, 2019). Northern Ireland has a coastline of 650km and you are never more than 35km away from the sea, as such coastal recreational activities and tourism are significant with activities including wildlife spotting, angling, visiting blue flag beaches and other water sports. In 2018, there were more than one million visits to the Giants Causeway Visitor Centre, demonstrating the importance of coastal visitor attractions to tourism in Northern Ireland (Statistica, 2021).

In 2019, a total of 10.808 million overseas trips were made to Ireland, generating earnings of £5,846 million (CSOa, 2019). The natural, unspoilt environment and dramatic coastlines are a unique selling point for Ireland. An increasing number of people are engaging in water sports such as surfing, sea kayaking and sailing. In addition, an estimated, 107,000 overseas visitors engaged in angling while in Ireland in 2011 (Simpson, 2013).

Scotland's tourism industry contributes roughly £6 billion to the overall GDP (5%) and nature-based tourism in Scotland is estimated to provide £1.4 billion in income (Bryden *et al.*, 2010). During 2019, there were 2.31 million domestic overnight trips to Scotland's seaside and coastal locations, which generated an expenditure of £448 million (Bryden *et al.*, 2010). Overnight trips to Scotland's seaside and coastal locations made up 16% of all overnight trips to Scotland and represented 14% of the total expenditure by domestic overnight visitors in 2019. Scotland has 11,000 miles of coastline and the Irish Sea covers only a small percentage of it, however coastal tourism is not insignificant within the Solway and Clyde (Visit Scotland, 2021).

3.2 Fishing

The Irish Sea contains many important fisheries for shellfish e.g. (*Nephrops)*, king scallop (*Pecten maximus)*, queen scallop (*Aequipecten opercularis)*, crab species, lobster (*Homarus gammarus)* and whelk (*Buccinum undatum*), flatfish e.g. sole (*Solea solea)*, plaice (*Pleuronectes platessa)*, brill (*Scophthalmus rhombus)* and turbot (*Scophthalmus maximus*) and gadoids e.g. cod (*Gadus morhua)*, haddock (*Melanogrammus aeglefinus)* and whiting (*Merlangius merlangus*), providing many coastal communities with employment. As whitefish populations have dwindled, there has been an increasing significance placed on the *Nephrops* and scallop fisheries in the Irish Sea which are now the most economically significant fisheries in the Irish Sea ***(Table 3)***. In 2020, 792 tonnes and 943 tonnes of queen scallops and king scallops were landed in the Isle of man, which equates to £541,372 and £1,713,629 respectively. According to Ireland's Seafood Development Agency, *Nephrops* is an extremely valuable species, supporting an important fishing industry, with relatively recent landing estimated to be about 7,800 tonnes, representing a significant part (11.7%) of the total landings in European waters (Hara et al., 2020).

Table 3: *Irish Sea UK fishery statistics 2019 (MMO, 2019)*
**N.B. does not include Republic of Ireland (total of 12,975 tonnes of landings by Irish Vessels in the Irish Sea in 2019 (CSOb, 2019))*

	Tonnes	Value (£)	Species
Demersal	2,603	£3,818,000	e.g. haddock, dogfish, cod, skates and rays and monks
Pelagic	5,069	£2,199,000	Predominantly herring and a very small percentage of catch (0.15%) mackerel
Shellfish	21,923	£43,384,000	Scallops (33% of catch), *Nephrops* (27%), whelks (27%), crabs (10%), other shells fish (e.g. lobsters, mussels etc.) *Nephrops* have the highest value of £14,973,000

Fishing is highly valued not only for its importance in supporting livelihoods, but it also has social importance in the Irish Sea, contributing to a sense of place in terms of individual and community identities (Reed et al., 2013). Coastal communities surrounding the whole of the Irish Sea have deep rooted cultural connections with fishing meaning that the value of fishing exceeds purely economic services.

The Irish Sea Network

3.3 Climate regulation

Oceans store 20–35% of human-made carbon emissions (Khatiwala *et al.,* 2009). The carbon stored in costal and marine ecosystems is known as blue carbon and is the absorption and deposition of atmospheric carbon in the marine environment. Coastal and marine ecosystems are now known to store up to six times more carbon per unit area than all other forests, even undisturbed rainforests (Mcleod *et al.,* 2011). Examples of important blue carbon habitats in the Irish Sea include seagrass, saltmarsh, sediment, shellfish beds/reefs (e.g. Blue mussel beds), intertidal sand/mud flats, brittlestar beds. As an indication of their importance, healthy saltmarsh in the UK can sequester an exceptionally high level of carbon in the range of 2.35 to 8.07t CO_2 ha^{-1} yr^{-1}, with typical figures around 4.40–5.50t CO_2 ha^{-1} yr^{-1} (Stafford *et al.,* 2021). The majority of carbon is stored in the sediment (average of 56t C ha^{-1}) but it is also stored in the vegetation (average of 0.6t C ha^{-1}) (Gregg *et al.,* 2021). Additionally, one hectare of UK seagrass can store almost a tonne of carbon a year, however the UK lost an estimated 49% of its seagrass coverage from 1970s to 2005 (Hiscock *et al.,* 2005).

Whilst intact marine ecosystems are effective at sequestering and storing carbon, when marine habitats are damaged – whether by physical disturbance such as trawling, coastal erosion and development, or through climate change – they can't retain as much carbon and may switch from being a carbon store to a carbon source. There are currently no published papers documenting a carbon budget for the Irish Sea region as a whole.

Meanwhile, the Irish Sea is gaining socio-economic importance in its suitability for renewables to mitigate against climate change as interest in renewable energy developments in the Irish Sea has grown (see section 6.3). Such interest is projected to increase as nations work to reduce climate emissions and achieve international and national targets. Marine renewable energy adds to the Irish Sea's ability to mitigate against climate change and may provide just transitions for many employed in carbon heavy industries.

4. Political complexity

Under international law, the six Irish Sea nations claim territorial seas out to 12 nautical miles (nm). The four devolved UK administrations have devolved competency for specified activities within their territorial sea. In addition, both the UK[2] and Ireland have claimed Exclusive Economic Zones (EEZ, 200nm) beyond their territorial sea, though formal maritime boundaries in the border loughs of Carlingford and the Foyle have never been agreed (O'Higgins et al., 2019).[3]

There is a common basis of regional cooperation between Ireland and the UK (including its devolved administrations) in addressing environmental conflicts and the management of activities occurring in, or impacting upon, the Irish Sea through international legislation such as the United Nations Convention on the Law of the Sea (UNCLOS), the Convention on Biological Diversity (CBD) and the EU Directives. Although the UK left the EU in 2021, the Trade and Cooperation Agreement 2021 states that the UK should remain consistent if not, go beyond, the EU standards for the environment. The UK has retained several pieces of legislation derived from EU Directives and has created new ones where appropriate (i.e. Fisheries Act 2020). The Isle of Man is a self-governing British Crown Dependency and although it has never been a member of the EU, it has been a signatory to various components of EU legislation through the UK.

Whilst all six Irish Sea nations are signatory to international instruments, such as UNCLOS and the CBD, they work in different ways, with differing priorities, policies, legislation and targets, making management of the Irish Sea complex. Appendix I lists the different governing bodies and statutory agencies working around the Irish Sea, highlighting complexity to bureaucracy and management. Variable engagement with, and implementation of, the EU Marine Spatial Planning (MSP) Directive can serve as a good example of this; within the Irish Sea, there are a large range of marine plans ***(Table 4)*** and policies which apply to certain sections making coherent management of the ecosystem as a whole difficult ***(Figure 4)***. There are also discrepancies between the boundaries of MSP compared to that of other devolved responsibilities (for example Marine Protected Areas) which adds a further layer of complexity in the management of the Irish Sea (see case study 4).

[2] As a Crown Dependency, the UK EEZ includes the Isle of Man.
[3] Previous inaction on transboundary issues (for example unregulated aquaculture in Lough Foyle) has led to environmental vulnerabilities. Vertical and horizontal cooperation mechanisms are crucial for successful marine management.

The Irish Sea Network

Table 4: Status of Marine Plans around the Irish Sea

Name	Nation	Status	Interactive map
North West Inshore and Offshore	England	Adopted 2021	
Scottish National Marine Plan	Scotland	Adopted 2015	tinyurl.com/y3uun7d3
Clyde Regional Marine Plan	Scotland	In development	
Solway Regional Marine Plan	Scotland	In development	
Isle of Man Marine Plan	Isle of Man	Marine Infrastructure Management Act was passed in 2016. However, limited secondary legislation has been finished and currently there is no marine plan.	
Northern Ireland National Marine Plan	Northern Ireland	Consulted on in April 2018, but to date it has not been published and adopted.	tinyurl.com/ycxa8v6z
Welsh National Marine Plan	Wales	Adopted 2019	tinyurl.com/bddxb6xb
The National Marine Planning Framework	Ireland	Adopted 2021	

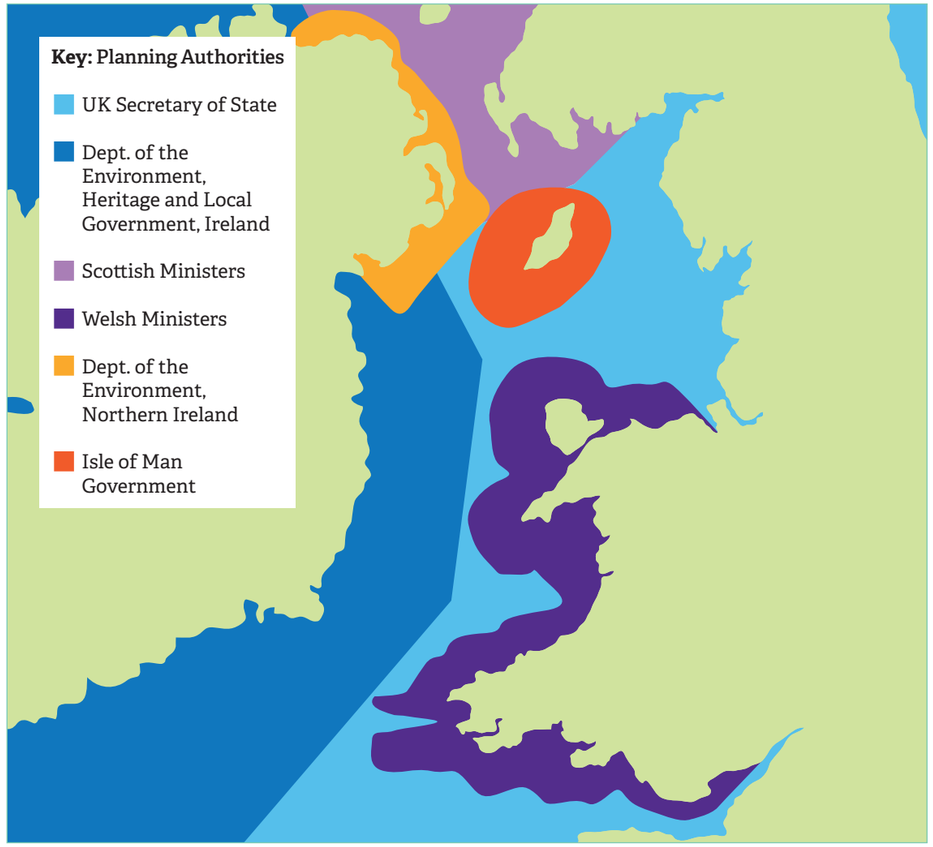


Figure 4: *Division of Marine Spatial Planning responsibilities in the Irish Sea (adapted from Kidd, 2013)*

➤ CASE STUDY 4: Ireland and the misalignment of development and management plans

In July 2021, Ireland's first Maritime Spatial Plan (MSP) the National Marine Planning Framework (NMPF) was formally published. The plan aims to bring together all marine based human activities and sets out visions, objectives and planning policies for each activity.

The NMPF was developed to fulfil the requirements of Directive 2014/89/EU – The Maritime Spatial Planning Directive. The MSP Directive sets out a number of objectives for maritime spatial planning (Article 5(1-3)); including objectives related to applying an ecosystem-based approach and contributing to the preservation, protection and improvement of the marine environment, including resilience to climate change impacts (among others).

The objectives of MSP are clear, however, significant issues with Ireland's NMPF remain. One of the most significant and pressing issues is that within the final NMPF Marine Protected Areas (MPAs) are excluded. The exclusion of MPAs is not pursuant with the objective of MSP as set out in Article 5(2) of the MSP Directive.

Given the absence of a legal mechanism to establish a network of MPAs in Ireland, Ireland's sea area will be utilised in support of a range of industrial activities such as Offshore Renewable Energy in advance of expanding its network of MPAs. With the absence of a legal definition of MPAs in Ireland and a mechanism to designate them, Ireland's marine environment is in a precarious position. There have been numerous calls by NGOs in Ireland to fast track MPA legislation and to resource and implement sensitivity mapping in the interim so that future development sites for industrial activities can be placed away from sensitive sea areas which may be required in the future MPA network. It was hoped that the Maritime Area Planning Act 2022 would address the disparity between offshore development and MPAs however this did not occur. Specific legislation for the designation of MPAs is expected in 2023.

A 2022 report commissioned by the Sustainable Water Network (SWAN) found numerous shortcomings in Ireland's approach to implementing MSP.[1] It is vital that the issues detailed in the report are resolved as a matter of urgency in order to implement an ecosystem based approach to MSP.

[1] https://swanireland.ie/wp-content/uploads/2022/05/An-Evaluation-of-Irelands-Marine-Spatial-Plan-The-National-Marine-Planning-Framework.pdf

Co-operation from 'bottom-up' groups working on the MSFD and MSP Directives have resulted in several efforts to develop regional and sub-regional fora for marine environmental management (e.g. Irish Sea Pilot project 2002–2004 and the Marine Spatial Planning Pilot 2004–2006), however, there is no legal requirement for governments to follow up on any specific recommendations (O'Higgins *et al.*, 2019). Another such group is the **Irish Sea Maritime Forum**, established in 2012, which includes representatives from a wide range of organisations including governments, marine planning authorities, other statutory agencies, NGOs, sector representatives and academia from all six jurisdictions around the Irish Sea; and facilitates marine planning knowledge exchange and capacity building across all administrative areas and sectors.

Ultimately, the successful regional implementation of Directives relies on the will of individual national governments (Cavello *et al.*, 2019). In some instances, the failure to adopt sustainable policies is a political choice more than a product of the complexity of international politics. Other regions of complex political environments provide good examples of management and cross border collaboration (case studies 5 and 6).

➤ CASE STUDY 5: Baltic Sea

In 2007, Baltic Sea countries jointly agreed under the HELCOM (the Helsinki Commission) Convention to develop a Baltic Sea Action Plan (BSAP) aiming to achieve good environmental status (GES) in the Baltic Sea by 2021, and emphasised the importance of basing Marine Spatial Planning (MSP) principles on an ecosystem-based approach. In 2010, HELCOM partnered with VASAB (Visions and Strategies Around the Baltic Sea - an organisation with a focus on transboundary planning issues) and developed 10 principles and guidelines to support the implementation of MSP in the region, with the HELCOM-VASAB MSP Working Group created to examine transboundary issues in MSP, amongst the other.

Challenges have included: different governance structures between countries (and within countries), which often lack coherent and integrated policies across sectors, disparity between requirements dictated by planning systems and sectorial regulations; competing interests; differing levels of stakeholder engagement and communication barriers (Kull *et al.*, 2021)

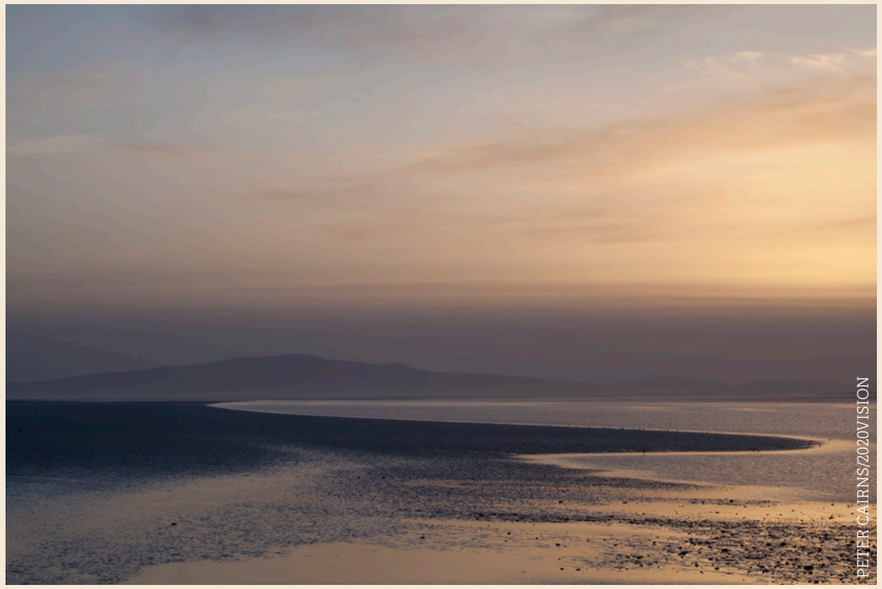
Nevertheless, since its adoption, the BSAP has resulted in a number of environmental improvements such as a reduction in nutrient inputs to the sea, a better state of biodiversity and a decrease in maritime incidents and spills. The BSAP It has been updated in 2021 with a Regional Maritime Spatial Planning Roadmap 2021-2030 which provides a concrete basis for HELCOM work. It incorporates the latest scientific knowledge and innovative management approaches into strategic policy implementation, and stimulates goal-oriented multilateral cooperation around the Baltic Sea region.

CASE STUDY 6: Solway Firth Partnership (O'Higgins *et al.*, 2019)

One initiative that fosters formal cross-border working and local input into decision-making is the use of coastal and marine partnerships. One such partnership is the Solway Firth (SWF) Partnership

Although this ecosystem is managed and regulated primarily under two pieces of legislation (the UK Marine and Coastal Access Act (MCAA) 2009 for the English side and the Marine (Scotland) Act 2010 for the Scottish), there is policy convergence under the UK Marine Policy Statement (HM Government 2011). This policy statement derives from Section 44 of the MCAA, whereby a joint policy statement outlines the general policies of the four respective administrations that contribute to the achievement of sustainable development of the UK's marine area. Approaches being applied in the SWF to ensure joint initiatives include:

- coordination of data sharing facilitated by Scotland's National Marine Plan interactive (webGIS) and the UK Marine Science Co-ordination Committee research platform;
- harmonisation of public budget and funding available on each side of the border from local councils and state agencies. The SWF Partnership has developed a common business plan for the SWF;
- coordination of SWF Regional Plan with Scotland National MSP;
- coordination of SWF Regional Plan with Scottish sectoral marine plans for offshore wind, wave and tidal energy; and
- joined up stakeholder involvement in the MSP process.



PETER CAIRNS/2020VISION

The Irish Sea Network

5. Climate change

Climate change will affect all aspects of the Irish Sea and its coastline and will impact all activities occurring in the region and management decisions. Understanding the effect of climate change (and complex additional stressors and activities e.g. pollution and fishing) in the Irish Sea is essential for management. Climate change impacts are transboundary issues that require collaboration on both sides of the Irish sea, multidisciplinary collaboration between governments, industry, researchers and NGOs, and cross border partnerships (BLUEFISH, 2021).

Current trajectories of greenhouse gas emissions lead to warming of 2.6–4.5˚C above pre-industrial levels by 2100, far exceeding the long-term goal of the Paris Agreement. There is already evidence that warming seas, reduced oxygen, ocean acidification and sea-level rise are affecting UK and Irish coasts and seas, with impacts on plankton, fish, birds and mammals.

PAUL NAYLOR

Distribution/abundance changes in response to climate change are species-specific and area specific dependent on historical and present dispersal and habitat suitability. In the Irish Sea, important keystone species (e.g. horse mussel *(Modiolus modiolus)*), are expected to decline (Hiscock *et al.*, 2004), whereas climate change accelerates the range expansion of other species, for example the European mussel *(Mytilus galloprovincialis)* and the invasive non-native species, the Pacific oyster *(Crassostrea gigas)* (King *et al.*, 2020). The distributions of several mobile species are also expected to move with temperature ranges and shifts in food availability. There has already been a rapid change in Atlantic mackerel distribution since 2007 with populations moving northward as sea temperatures rise. In UK waters, the lesser sandeel *(Ammodytes marinus)* is identified as being at particular risk from climate change. Owing to its strict association with coarse sandy sediments it is unable to adapt its distribution to compensate for warming sea temperatures. Sandeels are a key link in the food web, linking primary and zooplankton production to top predators (Heath et al., 2012).

Ocean acidification will impact calcifying species such as shellfish, but also calcifying planktonic organisms which may have indirect impacts of the food web. Acidification may also have a direct effect on fish sensory systems leading to subtle influences on behaviour with possible population-level implications.

Coastal flooding is likely to get worse, particularly on the North West of England's coastline[4], due to the combined effects of higher sea level rise than previously thought, as well as increased storminess and more extreme rainfall. Sea level rise along developed or rigid coastlines will reduce the habitat availability for some intertidal species and intertidal habitats (Smart *et al.,* 2021). Moreover, the predicted increase in annual rainfall will result in lowering salinity in estuarine systems. This may have significant impacts on species who rely on brackish water for survival. For example, decreased salinity levels may have a major negative impact on juvenile seabass and recruitment of this species (BLUEFISH, 2021).

Fisheries' productivity in some UK waters has already been negatively impacted by ocean warming and historical overexploitation, emphasising the need for sustainable management of fish populations that accounts for climate change impacts (UKCEH, 2020).

DANNY GREEN/2020VISION

[4] See Appendix 2 for map of land projected to be below annual flood level in 2050

6. Activities

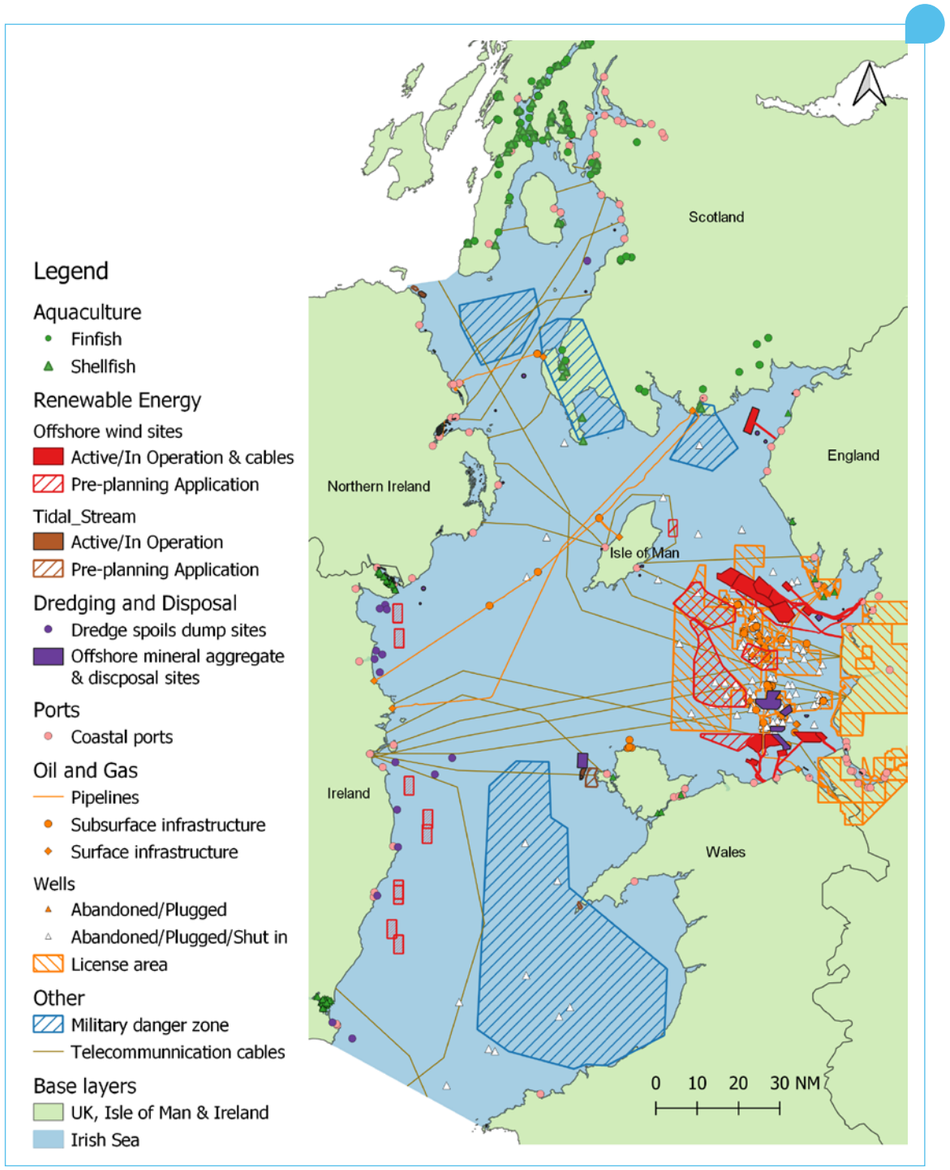


Figure 5: *Activities occurring in the Irish Sea. See Appendix 3 for data source*

See interactive marine planning maps for more detail: Northern Ireland Marine Map Viewer (daera-ni.gov.uk), Wales Marine Planning Portal (gov.wales), Marine Scotland – National Marine Plan Interactive (atkinsgeospatial.com).

6.1 Fishing

6.1.1 Status in the Irish Sea

The Irish Sea contains many significant fisheries for all six nations ***(Table 5)***, providing socio-economic benefits (section 3.2). Although Irish Sea fisheries have undergone considerable change in recent decades following the decline of commercially important finfish populations ***(Table 6)*** and their slow response to any imposed recovery plans (Bentley *et al.,* 2020)[4], fishing pressure remains high across the majority of the Irish Sea ***(Figure 6)***. As whitefish populations have dwindled there has been an increasing significance placed on the *Nephrops* and scallop fisheries[5], which are now the most economically significant fisheries in the Irish Sea. The most productive and lucrative area for the *Nephrops* fishery lies within the gyre of the western Irish Sea (ICES region VIIa, Functional Unit 15) and straddles the limits of the territorial seas of Ireland, Northern Ireland and the Isle of Man, as well as the UK and Irish EEZs ***(Figure 6)***.

The importance of the gyre in the western Irish Sea and the connectivity of fish stocks (as demonstrated by Case studies 1, 2 and 3) highlight that stock connectivity transcends geopolitical boundaries and confirm that these resources require cross-border management if populations are to be harvested sustainably.

EMILY BAXTER

[4] A number of emergency measures have been introduced since 2000 to conserve Irish Sea cod, including spawning area closures, vessel decommissioning schemes and catch reductions – but recovery has been slow and even in 2018 there was still no permitted commercial targeting cod (ICES, 2020).

[5] In 2021, a consultation was launched on how to improve the sustainability of the scallop fisheries.

The Irish Sea Network

Table 5: *Fishing activity by country. Data relevant to the Irish Sea where available. Please note Northern Ireland covers the whole of the fishing fleet and is not specific to the Irish Sea*

Country	Fishing activity
Scotland	Main activity in the Irish Sea is dredging for scallops around the Isle of Man performed by around 50 boats (mainly >10m). Pot fishing occurs along the Scottish side of the Solway Firth (22 vessels), and about 12 trawlers take part in the Irish Sea *Nephrops* fishery (ICES, 2018).
Isle of Man	The main fisheries in the Isle of Man's territorial sea are king scallop, queen scallop, crab, lobster, and whelk. A total of 73 vessels are licenced to fish for scallops and 40 vessels for queenies in Manx waters, made up of Manx, UK and Irish boats.
England & Wales	There are approximately 600 vessels (mostly <10m) that pot for whelks in the Irish Sea. There are 300 trawlers targeting a mixture of demersal fish populations. The English and Welsh *Nephrops* fleet in the Irish Sea comprises of around 25 vessels, 15 in the 10–15m vessel size, and fewer than 10 vessels that are <10m. There are also dredge fisheries, predominantly for king scallops (ICES, 2018).
Ireland	In total, approximately 500 fishing vessels are active per day in the waters of Ireland EEZ, although not all are operational in the Irish Sea. In the Irish Sea and St George's Channel, rays and flatfish dominate the landings of beam trawlers. In 2020, the Irish Sea ports of Clogherhead, Howth and Kilmore Quay landed 1,000 t, 4,600 t and 5,600 t of fish, respectively.
Northern Ireland	Northern Ireland's fleet consists of 332 vessels. There are approximately 140 over 10m vessels trawling for demersal species, mainly *Nephrops*, and landing whitefish as bycatch and with some scallop dredging. There are around 200 inshore vessels, mainly a potting fleet fishing crab and lobster. There is a modern pelagic fleet of three large (over 50m) vessels fishing for mackerel, herring and other small pelagic species. Demersal (*Nephrops*/whitefish and scallop) vessels dominate the Northern Irish fleet and are reducing in number. Please note, these figures are not specifically related to the Irish Sea.

Table 6: *Division 7.a. (Irish Sea) ICES estimates of landings. Weights are in tonnes*

	Sole	Cod	Whiting	Plaice	*Nephrops*	*Herring*
Landings: (late) 1980s	2,808	11,2900	11,856	6,220	8,128	10,172
Landings: Recent assessment (2018-2021)	34	181	1,118	465	7,521	3,896
% change	**- 98.8%**	**- 99.8%**	**- 90.6%**	**- 92.5%**	**- 6.6%**	**-61.7%**

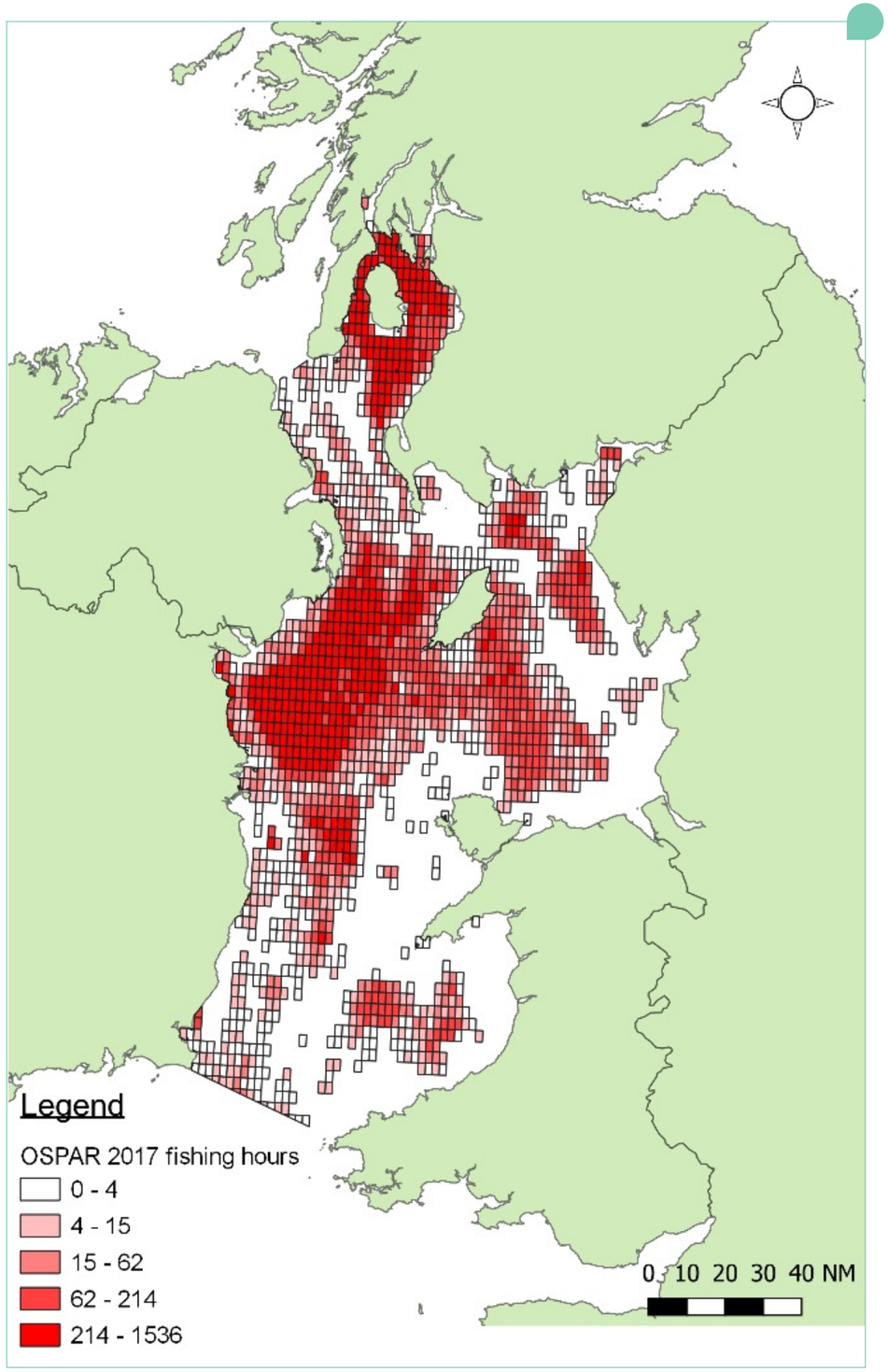


Figure 6: Total number of hours fished in 2017 for all gears, OSPAR. Datasets are available at ICES (2018a): https://doi.org/10.17895/ices.data.4686

6.1.2 Impact on marine environment

Fishing can have a significant impact on the marine environment; fishing depletes target and non-target populations of fish and other marine life, fishing reduces genetic diversity; destructive fishing practices damage essential habitats and carbon stores; fishing affects wider food-web dynamics and can reduce prey quality and foraging success in fish and other marine life populations; and fishing can entangle marine mammals, seabirds and turtles.

If not managed adequately, the removal of individuals from a population can have a significant effect on the future stock size through a reduction in spawning stock biomass and ultimately recruitment. For example, Irish Sea cod experienced a such a severe decline in spawning-stock biomass, attributed to overfishing, that in 1999 ICES advised that the stock was in danger of collapse, recommending that a recovery plan be put in place, with arguably limited success (Kelly *et al.*, 2006). Removing such large quantities of targeted (and non-targeted species) reduces genetic diversity and can alter behaviours and sizes in fish populations (Smith *et al.*, 1991; Jørgensen *et al.*, 2007).

Destructive fishing practices can damage sensitive habitat and reduce biodiversity. Diverse habitats, such as biogenic reefs, seagrass and low-energy sedimentary environments are highly sensitive to abrasion and damage from bottom trawls and dredges (Thurstan *et al.*, 2010). Changes to the habitat structure and complexity have the potential to cause significant, long-term changes to benthic ecosystems (OSPAR Commission, 2010). For example, trawling can reduce biodiversity in the top layers of seabed sediments by 50% (Pusceddu *et al.*, 2014). In heavily exploited areas, the dominant benthic species have been found to be opportunistic carnivores, with no fragile invertebrates present (Blanchard *et al.*, 2004). The Irish Sea mud belts are some of the most intensively trawled areas in European waters, with much of the area fished several times per year. For sites such as Mud Hole, sea pens were historically abundant but recent surveys have shown that sea pens are not present within the site and there is clear evidence of trawl scars across the site (Swift 1993; Defra, 2014).

The degradation or loss of habitat structure and complexity, and the process of overfishing, has knock-on effects on wider food web dynamics for fish and for marine megafauna and can cause trophic cascades which can completely restructure food webs (Baum and Worm, 2009). For example, commercially important fish (amongst other species) rely on these complex habitats for shelter, foraging, as well as nursery and spawning grounds (Turner 1999) and it has been shown in the north-eastern Irish Sea, that the reduction in habitat complexity and quality of prey species ultimately costs the fishing industry as it reduces the biomass and catches of affected commercially important species, such as cod and plaice (Johnson, 2015). Moreover, food web alterations can be seen further up the chain with reduced food availability (due to a combination of overfishing and climate change) being a key driver for seabird declines in the UK (Fayet *et al.*, 2021; Mitchell *et al.*, 2020). Case study 1 indicates the importance of the western gyre in the Irish Sea for Manx Shearwater. Overfishing and trawling has the potential to alter food availability for this species highlighting the impacts on the whole food chain (Dean *et al.*, 2015).

Bycatch, including entanglement in nets and ropes, is the unintentional capture of non-target species in fishing gear. Bycatch can affect biodiversity through impacts on top predators or species that are long-lived and have low reproductive rates, the removal of many individuals from any species, or by elimination of prey and is considered a waste of resources or unethical (Hall *et al.*, 2000). Many fisheries in the Irish Sea use trawls, purse seines and dredgers, which result in high levels of bycatch. *Nephrops* fisheries in ICES sub areas IV and VII which landed approximately 27,000 t of *Nephrops* in 2015 are categorised as 'very high risk' in terms of potential non-compliance with the landing obligation due to the level of bycatch and stock status of gadoid species. Several species depleted by past fishing effort, are now on the OSPAR list of threatened and declining species, including cod, spurdog *(Squallus acanthias)*, the common skate complex (*Dipturus* spp.), angel shark and porbeagle *(Lamna nasus)*. Although there are zero Total Allowable Catches (TACs) or prohibited listings for these species, several of them remain vulnerable as bycatch to existing fisheries. Spurdog and the common skate complex are caught as bycatch in mixed demersal trawl fisheries and gillnet fisheries (ICES, 2019). Moreover, fisheries bycatch is one of the biggest threats to marine mammal populations (Hamilton and Baker 2019). However, there are efforts to improve selectivity in fisheries. For example square-mesh panels can improve selectivity in whitefish trawls (Fryer *et al.*, 2016), acoustic deterrent devices (pingers) can reduce the bycatch of some small cetacean species in gillnets and appropriately designed exclusion devices can reduce pinniped bycatch in some trawl fisheries, and various pot/trap guard designs that can reduce marine mammal entrapment (Hamilton and Baker 2019).

Lastly, fishing can impact marine carbon stocks. In the western Irish Sea, it has been estimated that between 20 and 50cm of mud has been removed from the seabed over a period of 20 years, as a result of bottom-trawling (Coughlan et.al., 2015). In addition to a reduction in habitat complexity and removal of macrofauna, bottom trawling also affects sedimentary carbon storage through disruption of the seabed and re-suspension of sedimentary organic carbon. There is also an effect on the depth and rate of organic carbon burial due to trawling induced changes to seabed communities involved in bioturbation and bio-irrigation. The disturbance of sedimentary carbon stores can re-mineralise organic carbon to CO_2, which has the potential to increase ocean acidification, reduce the buffering capacity of the seas and add to the build-up of atmospheric CO_2 (Sala *et al.*, 2021). Although it is unknown how much of the aqueous CO_2 is released to the atmosphere, the increase in CO_2 in the water column and sediment pore waters can have far-reaching and complex effects on marine carbon cycling, primary productivity and biodiversity (Atwood *et al.*, 2020; Legge *et al.*, 2020).

The Irish Sea Network

6.2 Aquaculture

6.2.1 Status in the Irish Sea

Marine aquaculture in the Irish Sea for England, Wales, Northern Ireland and the Republic of Ireland is predominantly confined to shellfish, principally mussels, but also Pacific oysters with annual production of shellfish values for Wales, Northern Ireland and the Republic of Ireland at £15.7 million, £5.0 million and £7.1 million, respectively (O'Higgins *et al.*, 2019). The Isle of Man is looking to trial native oyster aquaculture and the Welsh Government has intentions to increase aquaculture production and may be issuing licences for offshore finfish farming (Welsh National Marine Plan 2019).

Northern Ireland has a small amount of salmon aquaculture at Glenarm Salmon. Scotland is a leading global aquaculture producer focusing on farmed salmon and within the Irish Sea region (principally the Firth of Clyde) there are several companies cultivating salmon, as well as pacific oysters within the loch systems ***(Figure 5)***.

There is growing interest in using Scotland and Ireland's rich wild seaweed resources in a number of industries. Commercial wild seaweed harvesting can range in scale from a few kilos of hand-harvested seaweed to thousands of tonnes of kelp harvested mechanically. There is also growing interest in seaweed farming across the nations but limited progress has been made to date.

Throughout the Irish Sea, aquaculture sites are currently confined to inshore sites, generally within sheltered bays and inlets, but offshore expansion of the industry has the potential to cause increased spatial conflict with other activities, although it also opens up opportunities for to co-location.

6.2.2 Impact on marine environment

The principle ecological effect of mussel and oyster farming is localised changes to the seabed caused by nutrient rich waste products (including shells, shellfish and faeces) dropping from the mussel lines and oyster racks which can accumulate on the seabed and alter its physical, chemical and biological nature. This can subsequently change the community structure of the surrounding area because of the way they change the seabed substrate, increasing the amount of shell and nutrients. However, shellfish aquaculture may have a beneficial effect on the surrounding environment as their efficiency at filtering can help control populations of phytoplankton growth (Hulot *et al.*, 2020), ensuring healthy oxygen levels for the ecosystem (Rice *et al.*, 2008).

Salmon farming is an intensive activity and has multiple impacts on the marine environment. The open nature of salmon farms enable waste, such as fish faeces, uneaten food, chemical treatments, and medicines, to enter the surrounding waters. The release of organic and inorganic waste can threaten the health of marine wildlife (Tett *et al.*, 2018). The high density of salmon kept in the cages makes them vulnerable to disease outbreaks and pests (particularly sea lice), which can lead to

high mortality of farmed fish and pose a risk to wild fish in the vicinity, particularly to Atlantic salmon and sea trout. Additionally, escaped farmed salmon pose a threat to Atlantic salmon populations through competition for resources and genetic mixing, which can compromise the health and stability of wild populations. Other areas of concern include the unmanaged harvesting of wild wrasse for use as cleaner fish to control sea lice and the sourcing of wild fish for fish meal and fish oil to feed a growing industry (Alder *et al.*, 2008).

6.3 Renewable energy developments

The marine renewable energy sector has become an increasingly important industry in recent years due to its role as a solution to climate change and recent targets to reach Net Zero; the UK, Isle of Man and the Republic of Ireland have committed to achieving Net Zero carbon emissions by 2050 and Scotland have committed to achieving it by 2045.

6.3.1 Wind

Approximately 53% of the European offshore wind capacity comes from the UK, with an offshore wind capacity of 6836 MW. The Irish Sea is considered an important area for development (de Castro *et al.*, 2019). To date, there are currently 12 wind farms[7] operating in the Irish Sea, consisting of a total of 666 turbines and providing 2.87GW of power to England, Wales, Republic of Ireland and Scotland, and there many more in the concept development phase across the whole of the Irish Sea[8], particularly off the Eastern coast of the Republic of Ireland and through the Crown Estate's Round 4 leasing areas ***(Figure 5)***. The development of wind farms is seen as a key component of meeting net zero targets; current UK targets are to achieve 40GW of power from offshore wind by 2030, the Republic of Ireland has committed to 5GW of energy from offshore wind by 2030 and the Isle of Man has a target 75% of Manx's power to come from renewable energy by 2035. Moreover, the Northern Ireland Energy Strategy has committed to 1GW of offshore wind from 2030.

6.3.2 Wave and Tidal

Tidal energy production is still a relatively small contributor to renewable energy. It is however a growing industry with multiple proposals in the Irish Sea, with several projects in the marine licensing process in Northern Ireland (Torr Head and Fair Head) and in Wales (e.g. Holyhead Deep and West Anglesey Demonstration Zone, see case study 7 and ***Figure 5***). There are also ongoing and recurrent discussions of various tidal barrage schemes in the north eastern Irish Sea (the River Mersey, Dee Estuary, Wyre Estuary and Solway Firth) and tidal lagoon schemes across the English and Welsh coasts.

[7] Walney 1, Walney 2, Walney Extension, West of Duddon Sands, Ormonde, Barrow, Burbo Bank, Burbo Bank Extension, Gwynt y Mor, Rhyl Flats, Arklow Bank (Phase 1), Robin Rigg

[8] Awel y Mor, Arklow Bank (Phase 2), Codling Wind Park, Codling Wind Park Extension, Oriel, Dublin Array.

The Irish Sea Network

CASE STUDY 7: Tidal energy in Wales

Wales has been identified as a key area for many offshore renewable projects including fixed offshore wind, floating offshore wind and marine renewables such as wave and tidal devices. Welsh Government aim to meet 70% of Wales' electricity demand from Welsh renewable electricity sources by 2030.

One of several proposed developments include the Morlais Demonstration Zone Project to west of Anglesey's Holy Island. The developer, Menter Môn Cyf, proposes a 35km^2 development in an area which corresponds to the West Anglesey Development Zone boundary. The project aims to establish Anglesey as a progressive energy hub, whilst maximising opportunities for local communities directly through employment and where possible indirectly through the establishment of a local supply chain. It forms one of two demonstration zones in Wales that has been identified as suitable for wave and tidal test and demonstration purposes. The Morlais Project seeks to provide a consented tidal technology demonstration zone with communal infrastructure such as export cables and substations for multiple tidal technology developers to install and test arrays of up to 620 tidal energy converters. Electricity will be bought to a substation onshore via a maximum of 9 sub-sea cables. It has the potential to become the largest tidal stream energy site in the world with a generating capacity of 240MW of electricity.

However, as with many proposed marine renewable developments, it is located in a biodiversity hotspot where the strong current that would drive renewable energy devices also provide nutrient-rich waters that attract many of the top predators which Wales is proud to support. Whilst the North Wales Wildlife Trust supports the role that renewable energy development has in reducing greenhouse gas emissions, it should not be at the expense of nature. The North Wales Wildlife Trust firmly believe that marine renewable developments need to be the right technology, in the right place and at the right scale.

NIA JONES

6.3.3 Impact on marine environment

6.3.3.1 Wind
The cumulative and in-combination effects on the marine environment from building offshore infrastructure on such a large scale could have significant impacts on the marine environment if not managed correctly. It is therefore important that the right technology is used in the right location. Impacts occur during the construction phases and the operational phase of developments.

During the construction phase of turbines, there is habitat damage and loss through both the footprint of the structure, and the cabling route (Degraer *et al.*, 2020), while noise from piling activities results in the relocation of fish species and marine mammals' distribution (Neo *et al.*, 2014; Brandt *et al.*, 2018). For example, pile driving can injure harbour porpoises in the immediate vicinity and cause disturbance up to 26km from the point of construction (Tougaard *et al.*, 2009).

Once installed, the submerged parts of turbine structures act as artificial reefs, providing new habitats in otherwise sandy areas (Degraer et al., 2020). The artificial reef effect is observed through the rapid and extensive colonization of offshore energy devices with sessile fauna, non-native species (Krone *et al.*, 2013; Farr *et al.*, 2021), the attraction of pelagic and demersal fish (Wilhelmsson *et al.*, 2006; Reubens *et al.*, 2014) to the devices and increased densities of large decapods at the scour protection (Krone *et al.*, 2013; Reubens *et al.*, 2014).

Other impacts include altering the hydrology of the area and the emission of electromagnetic fields (EMFs) from sub-sea power cables. Although research on the impacts of EMFs is limited there is indication that it may cause attraction of commercially important crustacea (e.g. Cancer pagurus; Scott *et al.*, 2018), as well as the possibility that EMFs may trigger developmental, physiological, and/or behavioural responses in sensitive fish and invertebrate species (Hutchison *et al.*, 2018).


EB OFFSHORE WIND FARM WALNEY

6.3.3.2 Tidal
Although there are not yet tidal barrages in the Irish Sea, barrages would have significant impacts on the area during construction and operation. During the construction phase there would be habitat loss and disturbance of benthic sediments causing sedimentation and smothering of nearby habitats, as well as noise impacts similar to those associated with offshore wind construction.

Once built, tidal barrages cause a significant effect on sea levels within the impounded basin, usually reducing the tidal range by about half which can completely alter vital habitats for birds and other marine life (Hooper and Austin, 2013). Barriers, such as dams and lagoons, can prevent anadromous fish (for example salmon, sea lamprey and shad) from reaching their freshwater breeding grounds and are a known factor in the decline and local extinctions of these species. Tidal developments also include the introduction of hard substrate in areas of soft sediment (such as muddy estuaries) that act to change the natural communities.

6.4 Ports and shipping

6.4.1 Status in the Irish Sea

The Irish Sea contains a considerable amount of maritime traffic. In 2020, approximately 109.1 Megatons (MT) of imports and exports passed through Irish Sea ports (CSO, 2021, ***Table 7***). In 2015, 27 MT, 55% of the total volume of goods received or forwarded by ship in Ireland passed through the Irish Sea, including 84% of goods traded by sea with the UK. For the UK, this volume makes up a much smaller, but nevertheless significant, proportion of total maritime trade (approximately 10%). Passenger travel across the Irish Sea is also very important and ferry services, cruise ships, and private vessels transport over 6 million people each year, the busiest port being Liverpool ***(Figure 7)***.

Table 7: Imports and exports passing through ports around the Irish Sea (CSO, 2021)

Port	Weight (MT)
Milford Haven	33.6
Liverpool	31.1
Dublin	25
Belfast	18.6
Manchester	7.1
Clyde	7.0

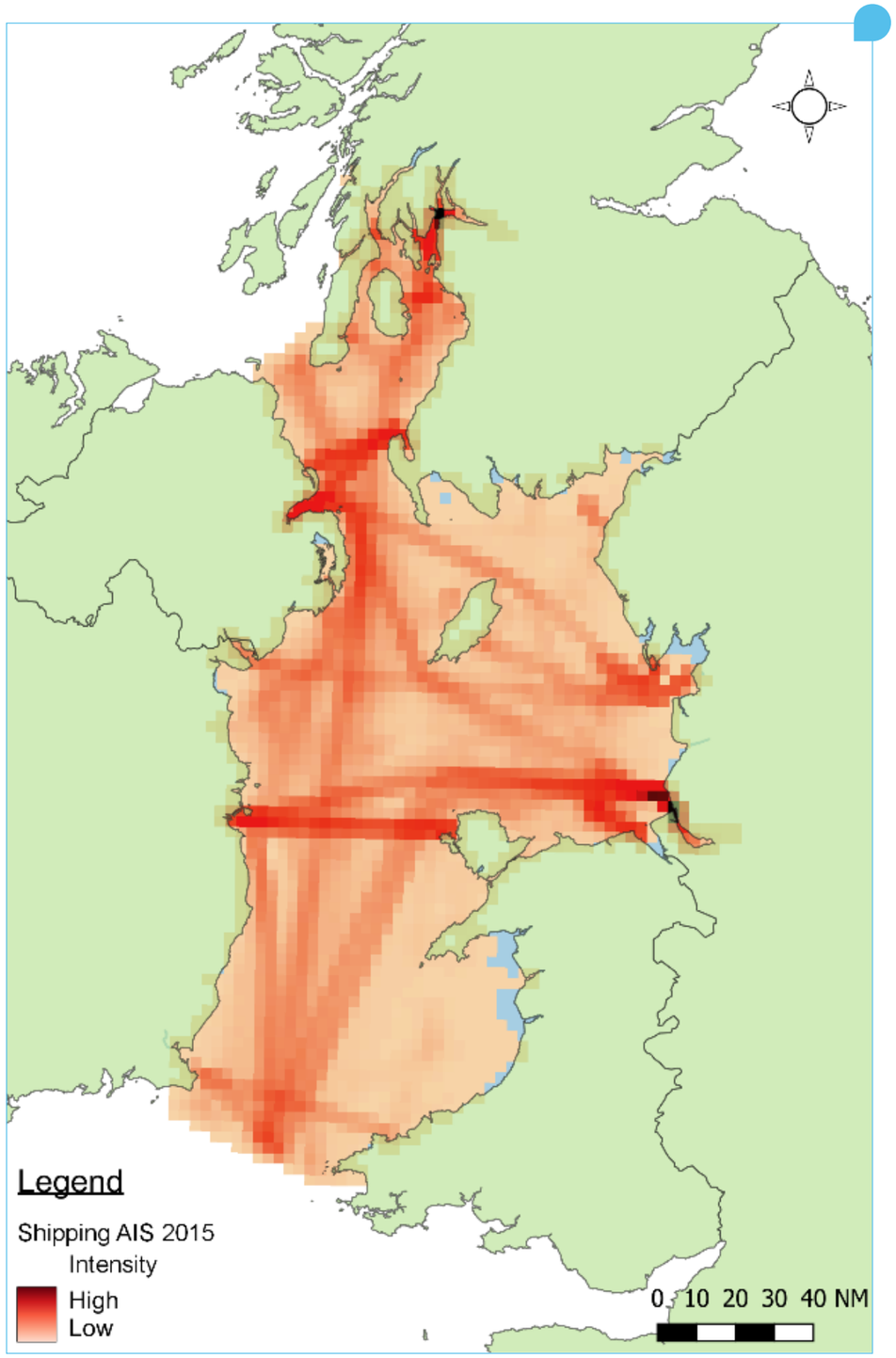


Figure 7: Shipping density map for AIS data from 2015, MMO. Published under Open Government Licence

6.4.2 Impact on the marine environment

There are number of different impacts that shipping can have on the marine environment. Firstly, there is a collision risk with marine megafauna, particularly around migratory routes, areas designated for marine mammals or areas of high tourism. Exposure to underwater noise pollution from shipping is also known to cause a range of detrimental effects in marine mammals, fish, and invertebrates, including heightened physiological stress levels (Wysocki *et al.*, 2006), disruption of behaviour (Nowacek *et al.*, 2007; Weilgart, 2018; Wisniewska *et al.*, 2018), and masking of acoustic communication (Putland *et al.*, 2018; Stanley *et al.*, 2017). Shipping also pollutes the marine environment through accidental spillages and illegal discharges of oil and commercial shipping can contaminate the marine environment with copper, nickel and zinc through antifouling coatings, ship exhaust-cleaning systems and sacrificial anodes which are easily corroded materials which prevent damage to the vessel's hull (Richir, 2021). The western Irish Sea gyre is at a disproportionate risk from environmental damage following an accidental summer-time oil spill. The currents acting in the gyre will cause contaminants to be retained in the area resulting in increased local damage (Hill *et al.*, 1997).

Species are known to be transported to new locations via international shipping and can then be spread via regional vessels and artificial structures (O'Shaughnessy, *et al.*, 2020). This ship-mediated transport can lead to the introduction of invasive species and pathogens, disrupting coastal ecosystem functioning and contributing to the spread of disease (de Castro *et al.*, 2017). The two primary shipping vectors by which invasive species are transported currently are ballast water and hull fouling, although regulations have been introduced in attempts to minimise this (Costello *et al.*, 2022)[10]. A number of invasive species in the Irish Sea include the leathery sea squirt *(Styela clava)*, the carpet sea squirt *(Didemnum vexillum)*, Chinese mitten crab *(Eriocheir sinensis)*, acorn barnacle *(Austrominius modestus)*, Pacific oyster *(Crassostrea gigas)*, Atlantic jackknife clam *(Ensis leei)* and slipper limpet *(Crepidula fornicata)*. Invasive non-native species can have significant impacts on both biodiversity and the economy as they can displace native species.

6.5 Recreation

Marine and coastal tourism and recreation around the Irish Sea have socio-economic importance across all six nations (section 3.1), however it can cause additional pressures to the marine environment and wildlife. For example, marine shipping provides collision risks to marine megafauna, particularly with high-speed leisure craft and in marine Special Area of Conservations (SACs) designated for their marine mammals (for example, the North Channel designated for harbour porpoise, *Phocoena phocoena*). Recreational shipping is covered within the density map in ***Figure 7***, with particular hotspots in the Firth of Clyde, around the Isle of Man, Carlingford Lough, Strangford Lough, Whitehaven, Llyn Peninsular (Appendix 5). Coastal development for recreation and tourism can cause damage and habitat loss, sedimentation and increased levels of pollution. Moreover, high levels of recreation on the coast can cause damage and disturbance to coastal wildlife. For example, in Pembrokshire there has been an increase in coastal tourism attributed to Covid and evidence of an increase in disturbance to seabirds, seals and cetaceans continues despite local voluntary codes of conduct. The increase in incidents has led to the formation of a police led group (including WTSWW and other eNGO's) to manage and respond to cases of marine wildlife disturbance in Pembrokeshire.

[10] International Convention for the Control and Management of Ships' Ballast Water and Sediments (2004) which entered into force in September 2017.

6.6 Aggregates

The UK marine aggregate dredging sector produces sand and gravel (aggregate) from licensed extraction areas around the coast. Within the UK sector of the Irish Sea, there are a number of areas licensed for dredging ***(Figure 5)***. A total of 10.7 million tonnes of marine sand and gravel was dredged from The Crown Estate licence areas between 1998 and 2017 and the cumulative area of seabed dredged during this time amounted to 12 km^2 (The Crown Estate, 2018).

Primary impacts of aggregate dredging result from the direct removal of sediment and associated benthic fauna, leading to loss of species diversity, abundance and biomass. This can change the species composition of an area and have compounding impacts throughout the food chain. For example, disrupting gravel substrates which are important spawning grounds for certain fish species (e.g. herring and sandeels) will have impacts on seabirds further up the chain (De Groot, 1986). Moreover, dredging causes turbidity within the water column and sedimentation. Smothering from increased sedimentation can harm benthic organisms and increased turbidity can reduce the foraging success of fish, seabirds and other marine wildlife (Newell *et al.,* 2004). The time the seabed takes to recover from this damage is dependent on dredging intensity (Waye-Barker *et al.,* 2015).

6.7 Military activity

There are various naval bases and military activities operating in the Irish Sea ***(Figure 5)***. For example, HM Naval Base Clyde is the Main Operating and Support Base for the Royal Navy in Scotland. The management of all submarine and surface ship maintenance, together with the provision of ancillary services, takes place in the area. There is a small Ministry of Defence (MOD) range at Eskmeals in Cumbria. Additionally, MOD Aberporth Range is situated in Cardigan Bay north of the Milford Haven Waterway beyond Strumble Head. The landward range covers some 550 acres and is the base for the testing of air launched weapons and Unmanned Aerial Systems (UAS). The Range has a Sea Danger Area which covers 6,500 square kilometres of Cardigan Bay from sea level to unlimited height. The construction of naval vessels and the operation of shore bases can have similar impacts to other coastal developments on coastal habitats and processes, for example altering hydrology, causing smothering and damaging habitat. Naval operations generating high intensity underwater sounds may impact upon cetacean and other marine species (National Research Council, 2003).

6.8 Pollution

6.8.1 Contaminants

Nearshore and coastal waters include some of the most productive marine ecosystems in the world and are crucial to the life history and development of many aquatic organisms. These habitats are strongly susceptible to pollution from anthropogenic input via rivers, marine traffic and coastal industry (Nicolaus *et al.,* 2016). The total human population residing within 10km of the Irish Sea's coastline is estimated at 6 million people and so pollution levels entering the Irish Sea can be high (Vincent *et al.,* 2004).

Increased nutrient input can cause eutrophication. Eutrophication is the excessive richness of nutrients in a body of water, which causes a dense growth of plant life and death of animal life from lack of oxygen. The most important sources contributing to eutrophication in inlets, estuaries, and harbours in the Celtic Seas ecoregion are agriculture, atmospheric deposition, urban wastewater, industry, and aquaculture (ICES 2020). For example, a recent Irish report highlighted that along the Irish coast of the Irish Sea area, 3 areas (Malahide, Dublin and Arklow) failed EU treatment standards in 2020 and 5 areas are discharging raw sewage (Omeath, Howth, Avoca, Arklow and Kilmore Quay). In England, un-treated effluent, including human waste, was released into waterways for more than three million hours in 2020, according to figures published by the Environment Agency (Environment Agency, 2021). Although most coastal and offshore waters of the Irish Sea are not eutrophic, a large region of North West England is a nitrate vulnerable zone due to anthropogenic nutrient enrichment and associated elevated phytoplankton biomass in Liverpool Bay (Gowen *et al.,* 2008). This warrants continued monitoring of the nutrient status, productivity and phytoplankton community structure of the region (Gowen *et al.,* 2008).

Marine pollutants such as toxins (including DDT, Furan, Radioactive waste, pesticides, PCB, TBT, Phenol etc.) do not dissolve or get fragmented and therefore can be very dangerous to marine life. PCBs banned over 20 years ago are still found in fish liver tissues at concentrations which may pose a health risk to both the individual fish and their predators. Low-level radioactive waste has been discharged into the Irish Sea as part of operations at Sellafield since 1952. Radioactive influence (caesium-137 and tritium) have been reported in the eastern Irish Sea (including Liverpool Bay) along the coast to the north and south of Sellafield, with levels decreasing with distance from the coast, and overall caesium-137 concentrations in the Irish Sea showing a decreasing trend (van der Kooji *et al.,* 2021). However, plans for more reactors in the UK with exploration of the storage of radioactive waste under the Irish Sea may well impact this.

A large number of anthropogenic substances in the marine environment are suspected of being endocrine disrupters and a growing number of studies have found examples in the UK marine environment (Scott et al., 2007). Endocrine disrupters tend to accumulate in the sediment and therefore may have a greater impact on bottom dwelling flat fish, diverting metabolic resources away from growth and spermatogenesis in male fish. Flounder *(Platicthys flesus L.)* caught in the Mersey, England, had abnormally elevated concentrations of vitellogenin (VTG) in their plasma—evidence of the presence of natural and synthetic oestrogens and/or xenoestrogens in the Mersey (Kleinkauf *et al.,* 2004).

6.8.2 Marine plastic pollution

Marine plastic pollution is an issue that has become one of increasing familiarity and growing public concern. Plastic pollution can enter the marine environment via a number of pathways including directly (by beach visitors, discarded or lost fishing gear from fishing vessels, illegal dumping) and indirectly (riverine flow from land-based sources or wastewater plants). Plastic pollution on beaches and in the sea will remain in the marine environment for centuries, harming wildlife through ingestion and entanglement. A study undertaken by Greenpeace found that out of 13 river systems sampled across England, Wales, Scotland and Northern Ireland, the river Mersey was most heavily polluted with plastic (Santillo *et al.*, 2019). Moreover, a study investigating the presence of ingested microplastics in gastrointestinal tract of *Nephrops* collected from five Irish prawn grounds found that samples from the North Irish Sea recorded the highest proportion of individuals positive for microplastic ingestion (83.33%), indicating the widespread and alarming nature of plastic pollution (Hara et al., 2020), which is consistent with other studies documenting high levels of plastic in the Irish Sea (Maes *et al.*, 2018; Martin *et al.*, 2017).

6.8.3 Noise pollution

As previously discussed (see sections shipping, renewables) marine noise pollution from anthropogenic sources has become increasingly recognised as an issue of major significance which can cause injury and disturbance to marine mammals and fish as well as behavioural changes including changing communication and foraging behaviours.

7. Marine Protected Areas

7.1 Designation and commitments

The activities occurring in the Irish Sea are altering the ecological balance of the region, depleting wildlife populations beyond safe biological limits and jeopardising what we take from the sea. It is therefore essential that a comprehensive and coherent network of MPAs exists to protect key habitats and wildlife.

'Marine Protected Area' is a globally recognised term for an area that can help support the conservation of marine habitats and species and covers a range of designations. Within the Irish Sea, there are a number of different types of MPAs, with varying levels of protection. The different names and types of protection once again adds to the complexity of managing the Irish Sea ***(Table 8)***, as does the different targets of government for how much of their seas are protected ***(Table 9)***.

The Irish Sea Network

Designation and Origin	Scope	Ownership and purpose
National		
Marine Conservation Zone (MCZ) – Marine Coastal Access Act, 2009; Northern Ireland Marine Act (2013).	England, Wales, Northern Ireland	Protect a range of nationally important, rare or threatened habitats, species and geological/ geomorphological features.
Marine Nature Reserve (MNR) – Isle of Man Wildlife Act 1990 (as amended)	Isle of Man	Protect marina flora, fauna, geological or physical features of special interest, or providing opportunities to study or research such features and can include zoned areas with varying levels of protection (to date only in Ramsey Bay MNR).
Natural Heritage Area (NHA) – Wildlife (Amendment) Act, 2000	Republic of Ireland	Protect one or more species, communities, habitats, landforms or geological or geomorphological features, or for its diversity of natural attributes. (Coastal/marine sites have been proposed as NHAs but none have yet been designated, 2021).
Statutory Nature Reserves (SNR) – Wildlife (Amendment) Act, 2000	Republic of Ireland	State owned, inland waters or foreshore areas that form the habitat of a species or community of flora or fauna of scientific interest or that is part of an ecosystem of scientific interest, and which would benefit from protection measures.
Site of Special Scientific Interest (SSSI) – National Parks and Access to the Countryside Act, 1949	England, Wales, Northern Ireland	Also Area of Special Scientific Interest (ASSI), are designated due to the rare species of fauna, flora, geological or physiological features.
Nature Conservation Marine Protected Areas (NCMPA) – Marine and Coastal Access Act 2009, Marine (Scotland) Act 2010	Scotland	Protect species and habitats in Scotland. Scotland also have Historic MPAs (for protecting historical features, e.g. ship wrecks) and Development and Research MPAs (for trialling and developing novel approaches to marine management).
Highly Protected Marine Areas (HPMAs) – Marine and Coastal Access Act 2009	England, Scotland	The UK Government has committed to identify and designate pilot Highly Protected Marine Areas (HPMAs) in English waters by the end of 2022, designated for the protection and recovery of marine ecosystems. They prohibit extractive, destructive, and depositional uses, allowing only non-damaging levels of other activities to the extent permitted by international law.
European		
OSPAR – OSPAR Convention, 1972		Has been promoting the establishment of a network of MPAs in the Northeast Atlantic (Europe) since 1998 to protect, conserve, and restore ecosystems and prevent their degradation (OSPAR Commission 2016).
Special Area of Conservation (SAC) – Habitats Directive, 1992		Protect habitats and species listed on Annex I and Annex II of the Conservation of Species and Habitats.
Special Protection Area (SPA) – Birds Directive, 1979		Area classified under the Birds Directive for the conservation of wild birds.
Natura 2000 – Habitats Directive, 1992		A network of breeding and resting sites for threatened species and habitats. A site must be a designated SAC or SPA to become part of the Natura 2000 network.
Ramsar Sites – Ramsar Convention, 1971		Wetlands of international importance.

Table 9: Commitments to Marine Protected Areas

Region	Position
England	Commitment to: conserve or protect at least 30% of domestic ocean by 2030; to pilot Highly Protected Marine Areas
Isle of Man	Supports 30x30
Northern Ireland	Supports protecting 30% of NI seas by 2030. MPA network must be ecologically coherent and well-managed.
Republic of Ireland	Committed to 30% protection by 2030. The existing 10% target which was to be achieved by 2020 will be achieved as soon as is practical.
Scotland	Committed to: implementing management measures throughout all MPAs; Designating 10% of Scottish waters as HPMAs by 2026.
Wales	Supports 30x30

7.2 The Irish Sea

Over the past 10 years, a considerable amount of work has gone into starting to develop a network of MPAs across the Irish Sea but with each nation working to their own targets, timescales and legislation, and a startling lack of active management. On paper, 36% of the Irish Sea is designated as an MPA, however in reality only approximately 5% has any management in place and less than 0.01% is fully protected (only Lamlash Bay, Isle of Arran and most of Strangford Lough SAC) ***(Figure 8)***.[11]

[11] For the purposes of this report, levels of protection are defined following the MPA Guide (Grorud-Colvert et al., 2021 and https://mpa-guide.protectedplanet.net/). (i) Fully Protected—no impact from extractive or destructive activities; (ii) Highly Protected—minimal impact; (iii) Lightly Protected—moderate impact; and (iv) Minimally Protected—high total impact, although still an MPA by IUCN criteria. Please note that the UK will be designating a series of HPMAs in English waters. One up for consultation (June 2022) is Allonby bay in the North West of England and if designated will increase the % of fully protected areas in the Irish Sea.

The Irish Sea Network

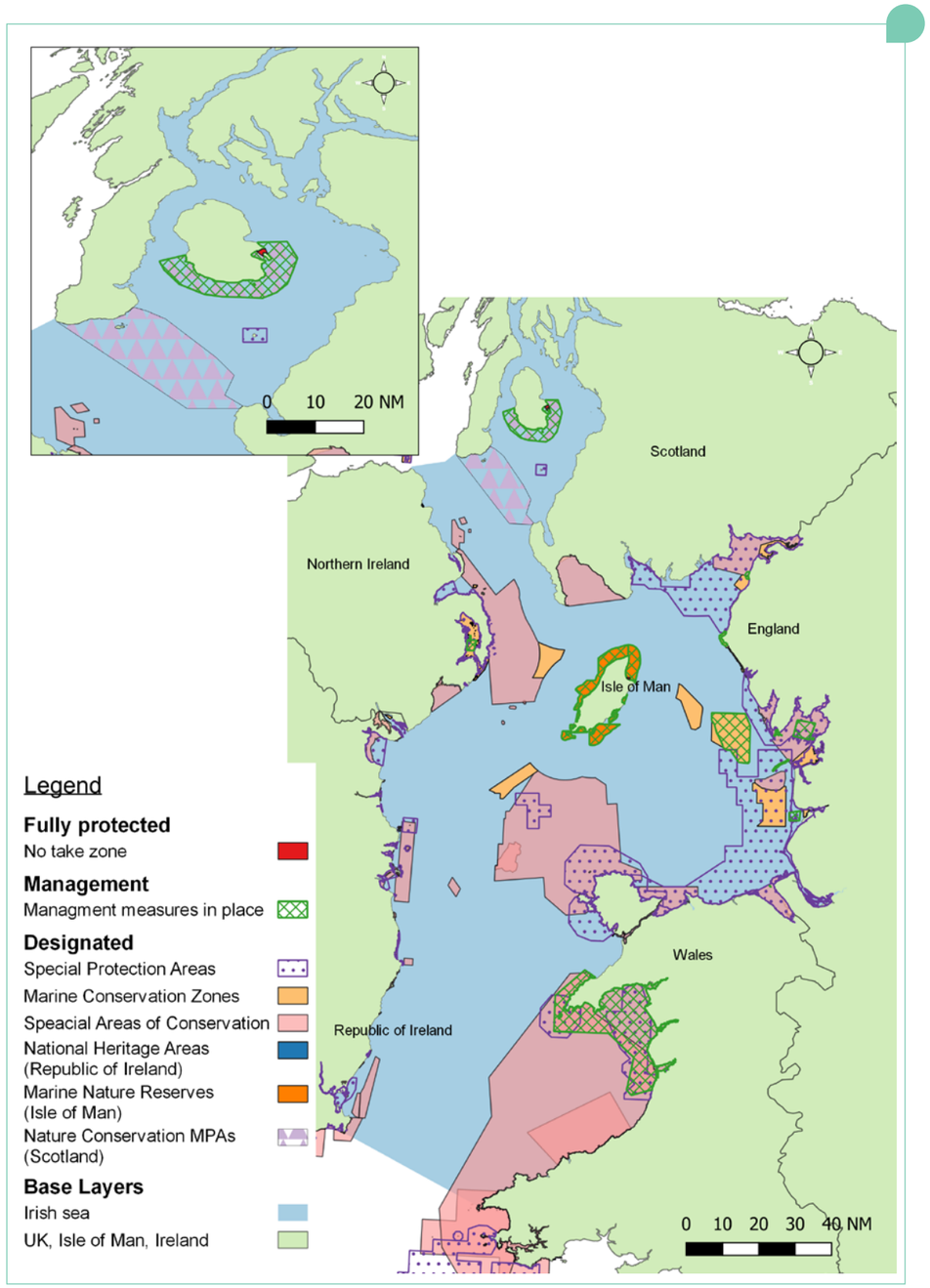


Figure 8: *Marine Protected Areas in the Irish Sea. See Appendix 5 for levels of protection. No Takes Zones = Fully Protected areas. Data from JNCC, Natural England, Scottish Natural Heritage, DAERA, Natural Resource Wales, North Western IFCA. UK Territorial Sea Limit. Please note that the UK will be designating a series of HPMAs in English waters. One up for consultation is Allonby bay in the North West of England and if designated will increase the No Take Zones in this map.*

7.3 MPA effectiveness

To be effective, science has shown that areas need to be fully protected; MPAs that are lightly protected or minimally protected ***(Figure 9)*** act as red herrings in marine conservation because they create an illusion of protection and consume scarce conservation resources yet provide little or no social or ecological gain over open areas (Turnbull *et al.,* 2021). Marine planning and conservation efforts including Marine Protected Areas and Nature Based Solutions (see section 8.1) will need to be future proofed against climate change and new initiatives and designations should take climate change predictions into consideration. Mapping the areas where the likelihood of changes to the marine environment is high can help to prioritise where and how restoration interventions should be deployed. These changes include predicted shifts in habitats and communities and intertidal boundaries (coastal squeeze), propelled by species displacements and mass mortalities from future heat waves (Duarte *et al.,* 2020). Well-managed MPAs may help to build resilience to climate change, however, many of them are already affected by ocean warming and further climate change may potentially compromise their performance in the future.

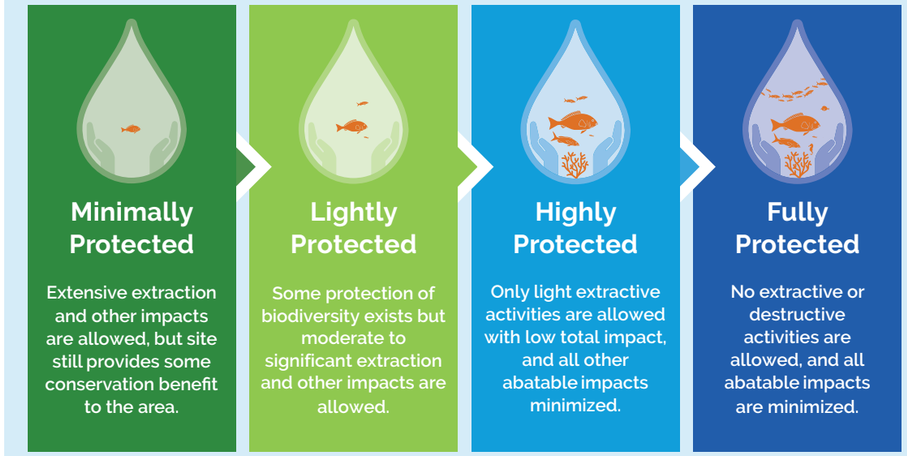


Figure 9: *Definitions of Marine Protected Areas and their levels of protection (IUCN WCPA, 2018)*

CASE STUDY 8: Lamlash Bay, Scotland

Lamlash Bay No Take Zone (NTZ) was designated in 2008 to protect maërl beds and promote the natural regeneration of all marine life in the area. The NTZ covers approximately one square mile at the north end of Lamlash Bay on the Isle of Arran. Since protection, biodiversity has increased substantially, along with the size, age and density of commercially important species such as the king scallop *(Pecten maximus)* and the European lobster *(Homarus gammarus)*. Some species have increased by 400% since the NTZ was established (Stewart *et al.,* 2020). The NTZ now sites within a 280km^2 MPA, which has shown even more pronounced biodiversity recovery after just 3.5 years of protection, with scallop densities over six-fold higher than in baseline studies before the MPA was enforced. Arran's conservation success has been recognized internationally and is inspiring greater involvement of local communities around the UK, and further afield, to take the destiny of their coastal waters into their own hands.

CASE STUDY 9: Ramsey Bay

Ramsey Bay Marine Nature Reserve (MNR) covers 96.98km^2 off the north eastern coast of the Isle of Man and has 5 different management zones; Horse Mussel, Conservation, Eelgrass, Rocky Shore and Fisheries with differing levels of protection and activities prohibited/allowed in each zone. The eelgrass zone is the nearest thing to a 'no-take' zone, with no potting, trawling, dredging, angling, or any other extraction method for living resources (except for lugworm and razorshell collection for bait between 1 October and 31 March). the eelgrass zone covers 0.5km^2, 0.01% of Manx waters. Due to early engagement between fishermen and DEFA (Department of Environment, Food and Agriculture,) Ramsey Bay MNR was established in agreement with the fishing industry (through the Manx Fish Producers Organisation which represents a large proportion of the industry) making enforcement much easier. Ramsey Bay was closed to scallop fishing as an Emergency Closed Area in November 2009 and was designated an MNR in 2011. As a result, scallops in the management zone are larger and more abundant. This benefits fishermen as it requires less time to travel and dredge to collect their quota as well as enabling a better market price.

LEIGH MORRIS

CASE STUDY 10: Ireland's failure to protect Natura 2000 sites

The EU has taken Ireland to court over wildlife habitat neglect. Marine Protected Areas (MPAs) in Ireland currently only exist in the form of Special Areas of Conservation (SACs) and Special Protection Areas (SPAs), collectively referred to as Natura 2000 sites. A report by the Irish Wildlife Trust, showed that the status of habitats inside MPAs is declining; vulnerable communities such as seagrass and maërl inside the habitat 'large shallow inlets and bays' are especially at risk with many assessed as unfavourable-bad under the most recent Habitats Directive reporting by the Irish Government to the European Commission (Classen, 2020). Lack of management and enforcement is causing the deterioration of ecosystems.

According to the report, failure is due to several factors:

- The policy adopted by the National Parks and Wildlife Service (NPWS) for activities inside protected areas allows 15% of damage. This policy is highly damaging to marine habitats and not compatible with the protection of habitats and species afforded under the Habitats Directive.
- Poor quality of 'Appropriate Assessment'/risk assessments (required under Article 6 of the Habitats Directive) with little consideration of cumulative pressures and lack of scientific certainty.
- Many marine Natura 2000 sites lack site-specific conservation objectives as required under the Habitats Directive.
- Harmful fisheries and aquaculture practices take place in Irish MPAs without adequate mitigation measures. This was confirmed by the European Commission in their referral of Ireland to the European Court of Justice due to failure to establish conservation measures in all Irish SACs.

In its complaint to the court, the Commission said Ireland identified 423 habitats as "sites of community importance" to be designated as SACs, but 154 of the sites have not yet been formally designated as SACs despite the deadline expiring in December 2014. Site-specific conservation objectives have not been established for 87 sites, and the necessary conservation measures have not been established at any of the 423 sites.

8. Opportunities

8.1 Highly Protected Marine Areas

The UK Government has committed to identify and designate pilot Highly Protected Marine Areas (HPMAs) in English waters by the end of 2022[12]. Scotland has committed to 10% of their seas being highly protected by 2026. HPMAs are areas of the sea designated for the protection and recovery of marine ecosystems. They prohibit extractive, destructive, and depositional uses, allowing only non-damaging levels of other activities to the extent permitted by international law. HPMAs will aid natures recovery, protect biodiversity and build resilience to climate change.

8.2 Nature Based Solutions

Nature-based solutions (NBS) harness the benefits of nature to address societal problems, like climate change, by restoring, protecting and improving an ecosystem and maximising biological richness. Benefits of NBS include carbon storage, flood protection, sediment management, water quality and coastal stabilisation. The importance of NBS is increasing as society begins to recognise the position that wildlife plays in our world. There are a number of important NBS projects taking place around the Irish sea ***(Table 10)***.

SOLWAY FIRTH PARTNERSHIP

[12] In June 2022, Defra announced that five sites (one of which is Allonby Bay in the Irish Sea) will be out for consultation to be designated as an HPMA.

The Irish Sea Network

Table 10: Status of Marine Plans around the Irish Sea

Name	Details	Organisation	Location
Seagrass feasibility studies	Remapping the extent of seagrass and assessing feasibility of restoration projects.	Cumbria Wildlife Trust	Walney Channel, Cumbria, England
Seagrass restoration project	2019-2021 – First full scale seagrass restoration project in the UK. Over the 2 years of the project 1 million seeds were planted over a two-hectare area Seagrass Ocean Rescue	Sky Ocean Rescue, WWF, Swansea University	Dale Bay, Pembrokeshire, Wales
Seagrass Ocean Rescue	Working in partnership with WWF, Project Seagrass and Pen Llyn a'r Sarnau SAC to work with communities to establish 10 hectares of seagrass meadow in North Wales	North Wales Wildlife Trust	Anglesey & Pen Llyn, Wales
Blue Carbon Habitat Restoration Feasibility Study: Phase 2	Habitat suitability modelling for seagrass, saltmarsh, kelp and shellfish beds (native oysters, blue mussels) to inform prioritisation of local-scale sites for restoration. Models include condition data and pressure layers that are available. Development of recommended field methodologies to estimate blue carbon values of coastal habitats (seagrass, saltmarsh, kelp and shellfish beds (native oysters, blue mussels and horse mussels). Evaluation of the likely coastal protection provided by kelp along the Outer Ards Peninsula.	Ulster Wildlife	Northern Ireland
Native Oyster Nursery	Installation of a native oyster nursery in Bangor Marina. This is a demonstration project to test the approach in Northern Ireland and capture best practice and lessons learned through the development and installation of a live project to support improvements and roll out of a nursery network in Northern Ireland.	Ulster Wildlife Trust	Bangor Marina, Northern Ireland
Large-scale oyster restoration action plan	Subtidal and intertidal surveys of Strangford Lough, and application of Gunderson population dynamics to inform report on feasibility of large-scale sink-source native oyster restoration in Strangford Lough.	Ulster Wildlife Trust	Strangford Lough, Northern Ireland

CASE STUDY 11: Northern Ireland Oyster Restoration project

Ulster Wildlife Trust's Northern Ireland Oyster Restoration (NONI) project is aiming to restore the native oyster in the loughs of Northern Ireland.

The UK's native oyster *(Ostrea edulis)* populations have declined by 95% over the past 200 years due to historical overfishing, habitat loss, pollution and influx of diseases. With this decline, we have also lost the benefits they provide.

Oysters are filter feeders, and a single oyster can filter up to 240 litres of seawater per day. Their filtering ability can improve water quality, not only because they remove particles from the water, but also because they can deposit them on the sediment where conditions for bacteria that break down pollutants such as nitrates are better. By removing particles from the water column, the oyster can also increase light penetration to the sediment and promote the recovery of seagrasses, another threatened and valuable coastal habitats. The drawdown of sediments together with the stabilising effect of the reef can also result in reefs acting as carbon sinks although the ecosystem benefit is complicated.

The native oyster has been considered extinct in Belfast Lough since 1903. However, in the summer of 2020, surveys of Belfast Lough found the presence of live oysters for the first time in over 100 years (Smyth *et al.*, 2021). The return of the oyster to the lough unaided is evidence that the environmental conditions for establishment are appropriate, but to enhance the population, intervention from conservationists is required if they are to thrive again. Deploying a native oyster nursery in Bangor Marina has the potential to support the precarious population in Belfast Lough.

An oyster nursery is a micro-habitat housing 27 mature oysters which will reproduce and release the next generation of oyster larvae into the sea. An individual oyster can release up to 1 million larvae per year. In total, Ulster Wildlife Trust will install 24 oyster nurseries in Bangor Marina in hope that the larvae will be carried out in to Belfast Lough and enhance the small population.

In their larval stages, oysters have a preference for settling out on adult oysters forming dense aggregations, termed oyster reefs. Reefs provide food and habitat for numerous species and can serve as nursery grounds for some fish species. Future stages of the project would aim to restore parts of the seabed to improve and increase areas for the oyster larvae released by the oyster nurseries to settle.

In some communities a living memory of native oysters remains, but in others it has gone. This project will reignite the appreciation and cultural attachment to native oysters. A public engagement, education, and citizen science programme will be developed, aiming to educate and connect people with the sea through oysters to inspire the next generation of marine stewards.

The project is funded by the DAERA Challenge Fund and is in collaboration with Bangor Marina. The methodology is based on the Zoological Society of London's Wild Oyster Project.

The Irish Sea Network

8.3 Improved management and cooperation

The Irish Sea Network have identified the importance of collaboration across nations and strongly advocate for the value of co-operation between nations to protect people and planet. Increasing the capacity for, and effectiveness of, cross-border co-operation has the potential to improve ocean governance as a whole, minimise the duplication of effort and build momentum for marine recovery. The use of existing co-operation mechanisms (both legislative and institutional structures) is important but it should be recognised that new initiatives may also be required.

9. Conclusion

The Irish Sea is an important region ecologically with key habitats supporting a huge variety of wildlife. Internationally and nationally protected species rely on the Irish Sea for feeding, breeding and migrating. Moreover, a healthy marine environment underpins the economy, society and human well-being of the surrounding nations of the Irish Sea. Key habitats provide essential goods and services such as food provisioning, climate regulation, immobilisation of pollutants, clean water, tourism and recreation, health and wellbeing, and education. Yet the current state of the Irish Sea is degraded with significant and widespread anthropogenic pressures present throughout. Damaging activities such as some types of fishing and development put significant pressure on the marine environment. Shipping, pollution, aquaculture and recreational activities further degrade the marine environment if managed incorrectly. These pressures are increasing with a growing population and the expansion of offshore developments. In addition to these, climate change, if not already doing so, will affect all aspects of the Irish Sea and its coastline, placing more pressure on it.

Whilst there are efforts to protect the Irish Sea through Marine Protected Areas and Nature Based Solution initiatives, these do not go far enough - on paper, 36% of the Irish Sea is designated as an MPA, however in reality, only 5% has any management in place and less than 0.01% is fully protected. Nature Based Solutions are beginning to be implemented in the Irish Sea but these, along with MPAs, need to be future proofed by taking climate change into consideration and ensuring their effectiveness. The UK Government has recently committed to designating pilot HPMAs in English waters, one of which is at Allonby Bay in the Irish Sea. Whilst this is an excellent step in the right direction, more areas of the Irish Sea need to be fully protected to give nature space for recovery, in the context of increasing pressures.

The current pace and scale of change could have devastating effects if managed ineffectively, yet sustainable management of the Irish Sea is complicated by the fact that it is bordered by six different nations, all of which govern their territorial sea area with different priorities and, therefore, policies and legislation. Our review indicates that, ultimately, there are significant and increasing pressures on the Irish Sea, with insufficient management. Recent developments in policies surrounding the energy crisis and Net Zero, in addition to new thinking about marine recovery through HPMAs and Marine Net Gain, means that this review has come at a good time to take a 'stock check' on the Irish Sea. The marine environment is interconnected and many of the pressures and activities discussed in this report affect multiple parts of the Irish Sea simultaneously. These issues are transboundary and require multidisciplinary collaboration between governments, industry, researchers and NGOs, and cross border partnerships. A regional approach is key to managing the Irish Sea sustainably.

The Irish Sea Network

CHRIS GOMERSALL/2020VISION

References

Alder, J., Campbell, B., Karpouzi, V., Kaschner, K. and Pauly, D. 2008. Forage Fish: From Ecosystems to Markets. *Annual Review of Environment and Resources* 33, 153–166.

Atwood, T.B., Witt, A., Mayorga, J., Hammill, E. and Sala, E., 2020. Global patterns in marine sediment carbon stocks. *Frontiers in Marine Science*, 7, p.165.

Baum, J.K. and Worm, B., 2009. Cascading top- down effects of changing oceanic predator abundances. *Journal of animal ecology*, 78(4), pp.699-714.

Bentley, J.W., Serpetti, N., Fox, C.J., Heymans, J.J. and Reid, D.G., 2020. Retrospective analysis of the influence of environmental drivers on commercial stocks and fishing opportunities in the Irish Sea. *Fisheries Oceanography*, 29(5), pp.415-435.

Blanchard, F., LeLoc'h, F., Hily, C. and Boucher, J., 2004. Fishing effects on diversity, size and community structure of the benthic invertebrate and fish megafauna on the Bay of Biscay coast of France. *Marine Ecology Progress Series*, 280, pp.249-260.

BLUEFISH 2021, BLUEFISH Conference Report, **http://bluefishproject.com/wp-content/uploads/2021/10/WEB-Blue-Fish-Report_English-final.pdf**

Brandt, M.J., Dragon, A.C., Diederichs, A., Bellmann, M.A., Wahl, V., Piper, W., Nabe-Nielsen, J. and Nehls, G., 2018. Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. *Marine Ecology Progress Series*, 596, pp.213-232.

Bryden, D.M., Westbrook, S.R., Burns, B.R., Taylor, W.A. and Anderson, S. 2010. Assessing the economic impacts of nature based tourism in Scotland. Scottish Natural Heritage, Inverness. pp. 105

Cavallo, M., Borja, Á., Elliott, M., Quintino, V. and Touza, J., 2019. Impediments to achieving integrated marine management across borders: the case of the EU marine strategy framework directive. *Marine Policy*, 103, pp.68-73.

Central Statistics Office (CSOa), 2019, Tourism and Travel Quarter 4 2019, (last accessed 5/05/2022), **https://www.cso.ie/en/releasesandpublications/er/tt/tourismandtravelquarter42019/**

Central Statistics Office (CSOb), 2019, UK Sea Fisheries Statistics: Fish Landings (accessed 5.07.2021) **https://www.cso.ie/en/releasesandpublications/er/fl/fishlandings2019/**

Central Statistics Office (CSO), 2021, Statistics of port traffic quarter 4 year 2020, (accessed5.07.2021) **https://www.cso.ie/en/releasesandpublications/er/spt/statisticsofporttrafficquarter4year2020/**

Classen, R., 2020. Marine Protected Areas – Restoring Ireland's Ocean Wildlife II. Report on Ireland's Failure to Protect Marine Natura 2000 Sites. Irish Wildlife Trust.

The Irish Sea Network

Coscia, I., Wilmes, S.B., Ironside, J.E., Goward- Brown, A., O'Dea, E., Malham, S.K., McDevitt, A.D. and Robins, P.E., 2020, Fine- scale seascape genomics of an exploited marine species, the common cockle Cerastoderma edule, using a multimodelling approach. *Evolutionary applications*, *13*(8), pp.1854-1867.

Coscia, I., Robins, P.E., Porter, J.S., Malham, S.K. and Ironside, J.E., 2013. Modelled larval dispersal and measured gene flow: seascape genetics of the common cockle Cerastoderma edule in the southern Irish Sea. *Conservation Genetics*, *14*(2), pp.451-466.

Costello, K.E., Lynch, S.A., McAllen, R., O'Riordan, R.M. and Culloty, S.C., 2022. Assessing the potential for invasive species introductions and secondary spread using vessel movements in maritime ports. *Marine Pollution Bulletin*, *177*, p.113496.

Coughlan, M., Wheeler, A.J., Dorschel, B., Lordan, C., Boer, W., Van Gaever, P., De Haas, H. and Mörz, T., 2015. Record of anthropogenic impact on the Western Irish Sea mud belt. *Anthropocene*, *9*, pp.56-69.

Dean, B., Kirk, H., Fayet, A., Shoji, A., Freeman, R., Leonard, K., Perrins, C.M. and Guilford, T., 2015. Simultaneous multi-colony tracking of a pelagic seabird reveals cross-colony utilization of a shared foraging area. *Marine Ecology Progress Series*, *538*, pp.239-248.

de Castro, M., Salvador, S., Gómez-Gesteira, M., Costoya, X., Carvalho, D., Sanz-Larruga, F.J. and Gimeno, L., 2019. Europe, China and the United States: Three different approaches to the development of offshore wind energy. *Renewable and Sustainable Energy Reviews*, *109*, pp.55-70.

de Castro, M., Fileman, T.W. and Hall-Spencer, J.M., 2017. Invasive species in the Northeastern and Southwestern Atlantic Ocean: A review. *Marine Pollution Bulletin*, *116*(1-2), pp.41-47.

Day, J., Dudley, N., Hockings, M., Holmes, G., Laffoley, D.D.A., Stolton, S. and Wells, S.M., 2012. *Guidelines for applying the IUCN protected area management categories to marine protected areas*. IUCN.

Defra, 2014, Mud Hole rMCZ Post-survey Site Report, Contract Reference: MB0120 **http://randd.defra.gov.uk/Document.aspx?Document=12338_MudHolerMCZ_SummarySiteReport_V10.pdf**

Degraer, S., Carey, D.A., Coolen, J.W., Hutchison, Z.L., Kerckhof, F., Rumes, B. and Vanaverbeke, J., 2020. Offshore wind farm artificial reefs affect ecosystem structure and functioning. *Oceanography*, *33*(4), pp.48-57

De Groot, S.J., 1986. Marine sand and gravel extraction in the North Atlantic and its potential environmental impact, with emphasis on the North Sea. *Ocean Management*, *10*(1), pp.21-36.

Deloitte and Oxford Economics, 2010, The Economic Contribution of the Visitor Economy – UK and the nations. **http://www.deloitte.com/assets/Dcom-UnitedKingdom/ Local%20Assets/Documents/UK_THL_VisitorEconomy_ Sept08.pdf. Date of access 21/11/12. Cited in Simpson 2013**

Dolton, H.R., Gell, F.R., Hall, J., Hall, G., Hawkes, L.A. and Witt, M.J., 2020. Assessing the importance of Isle of Man waters for the basking shark Cetorhinus maximus. *Endangered Species Research, 41*, pp.209-223.

Duarte, C.M., Agusti, S., Barbier, E., Britten, G.L., Castilla, J.C., Gattuso, J.P., Fulweiler, R.W., Hughes, T.P., Knowlton, N., Lovelock, C.E. and Lotze, H.K., 2020. Rebuilding marine life. *Nature, 580*(7801), pp.39-51.

Environment Agency, 2021, **https://environment.data.gov.uk/dataset/21e15f12-0df8-4bfc-b763-45226c16a8ac**, Last accessed 5/05/2022

Farr, H., Ruttenberg, B., Walter, R.K., Wang, Y.H. and White, C., 2021. Potential environmental effects of deepwater floating offshore wind energy facilities. *Ocean & Coastal Management, 207*, p.105611.

Fayet, A.L., Clucas, G.V., Anker- Nilssen, T., Syposz, M. and Hansen, E.S., 2021, Local prey shortages drive foraging costs and breeding success in a declining seabird, the Atlantic puffin. *Journal of Animal Ecology, 90*(5), pp.1152-1164.

Fryer, R.J., O'Neill F.G., Edridge A., 2016. A meta- analysis of haddock size- selection data, *Fish Fish*. 17, pp. 358-374

Gowen, R.J., Tett, P., Kennington, K., Mills, D.K., Shammon, T.M., Stewart, B.M., Greenwood, N., Flanagan, C., Devlin, M. and Wither, A., 2008. The Irish Sea: is it eutrophic?. *Estuarine, Coastal and Shelf Science, 76*(2), pp.239-254.

Gregg, R., Elias, J., Alonso, I., Crosher I., Muto P and Morecroft M. 2021. Carbon storage and sequestration by habitat: a review of the evidence (second edition) Natural England Research Report NERR094. Natural England, York. Available at: **http://publications.naturalengland.org.uk/publication/5419124441481216** [Accessed 15/03/22]

Hall, M.A., Alverson, D.L. and Metuzals, K.I., 2000, By-catch: problems and solutions. *Marine pollution bulletin, 41*(1-6), pp.204-219.

Hamilton, S. and Baker, G.B., 2019. Technical mitigation to reduce marine mammal bycatch and entanglement in commercial fishing gear: lessons learnt and future directions. *Reviews in Fish Biology and Fisheries, 29*(2), pp.223-247.

Hara, J., Frias, J. and Nash, R., 2020. Quantification of microplastic ingestion by the decapod crustacean Nephrops norvegicus from Irish waters. *Marine pollution bulletin, 152*, p.110905.

Heath, M.R., Neat, F.C., Pinnegar, J.K., Reid, D.G., Sims, D.W. and Wright, P.J., 2012. Review of climate change impacts on marine fish and shellfish around the UK and Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems, 22*(3), pp.337-367.

Hiscock, K., Southward, A., Tittley, I.A.N. and Hawkins, S., 2004. Effects of changing temperature on benthic marine life in Britain and Ireland. *Aquatic Conservation: marine and freshwater Ecosystems, 14*(4), pp.333-362.

Hiscock, K., Sewell, J., Oakley, J., 2005, *Marine health check 2005: A report to gauge the health of the UK's sea-life*, for WWF-UK, **http://www.marlin.ac.uk/assets/pdf/marine_healthcheck05.pdf**

Hooper, T. and Austen, M., 2013. Tidal barrages in the UK: Ecological and social impacts, potential mitigation, and tools to support barrage planning. *Renewable and Sustainable Energy Reviews, 23*, pp.289-298. **https://www.sciencedirect.com/science/article/abs/pii/S1364032113001500**

Hulot, V., Saulnier, D., Lafabrie, C., and Gaertner-Mazouni, N. 2020. Shellfish culture: a complex driver of planktonic communities. *Reviews in Aquaculture*, 12: 33–46

Hutchison Z., Sigray P., He H., Gill A. B., King J., Gibson C. 2018. Electromagnetic Field (EMF) Impacts on Elasmobranch (Shark, Rays, and Skates) and American Lobster Movement and Migration From Direct Current Cables. OCS Study BOEM 2018-003. U.S. Department of the Interior, Bureau of Ocean Energy Management, Sterling, VA. 148 pp. + appendices.

ICES, 2018, Fisheries Overview Celtic Seas Region, **https://www.ices.dk/sites/pub/Publication%20Reports/Advice/2018/2018/CelticSeasEcoregion_FisheriesOverviews.pdf**

ICES, 2020, Working Group for the Celtic Seas Ecoregion, Scientific Reports 2:40, **https://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/Fisheries%20Resources%20Steering%20Group/2020/WGCSE/07_Section5_Cod_7a_2020.pdf**

IOM Gov, 2018, Isle of Man Passenger Survey, **https://www.gov.im/about-the-government/departments/cabinet-office/statistics-isle-of-man/passenger-survey/, last accessed 05/05/2022**

Irish Research Council (IRC), New Horizon Project, 2019, **https://culturalvalueofcoastlines.com/about/the-irish-sea/** (Last accessed 01/06/22)

ISCZ, Irish Sea Conservation Zones Project, 2011, Final Recommendations, Section 3.1 Selection Assessment Documents **http://publications.naturalengland.org.uk/file/1732875**

IUCN WCPA, 2018. Applying IUCN's Global Conservation Standards to Marine Protected Areas (MPA). Delivering effective conservation action through MPAs, to secure ocean health & sustainable development. Version 1.0. Gland, Switzerland. 4pp

Jørgensen C, Enberg K, Dunlop ES, Arlinghaus R, Boukal DS, Brander K, et al. 2007. Ecology: Managing evolving fish stocks. *Science* (80-);318: 1247–1248. doi:10.1126/science.1148089

Johnson A.F., Gorelli G, Jenkins SR, Hiddink JG, Hinz H. 2015 Effects of bottom trawling on fish foraging and feeding. Proc. R. Soc. B 282: 20142336. **http://dx.doi.org/10.1098/rspb.2014.2336**

Johnston, E. 2021, The basking shark *Cetorhinus maximus*: movement, behaviour and connectivity in the Northeast Atlantic. *Student thesis*: Queen's University Belfast

Kelly, C.J., Codling, E.A. and Rogan, E., 2006. The Irish Sea cod recovery plan: some lessons learned. *ICES Journal of Marine Science, 63*(4), pp.600-610.
Khatiwala, S., Primeau, F,. and Hall, T., Nature, 2009, *Reconstruction of the history of anthropogenic CO_2 concentrations in the ocean*, **https://www.nature.com/articles/nature08526**

King N., Wilmes S.B., Smyth D., Tinker D., Robins P., Thorpe J., Jones L., Malham S.K., 2020, Climate change accelerates range expansion of the invasive non-native species, the Pacific oyster, *Crassostrea gigas. ICES Journal of Marine Science*. 78(1), DOI: 10.1093/icesjms/fsaa189

Kleinkauf, A., Scott, A.P., Stewart, C., Simpson, M.G. and Leah, R.T., 2004. Abnormally elevated VTG concentrations in flounder (Platichthys flesus) from the Mersey Estuary (UK) – a continuing problem. *Ecotoxicology and environmental safety, 58*(3), pp.356-364.

Krone, R., Gutow, L., Joschko, T.J. and Schröder, A., 2013. Epifauna dynamics at an offshore foundation–implications of future wind power farming in the North Sea. *Marine environmental research, 85*, pp.1-12.

Kull, M., Moodie, J.R., Thomas, H.L., Mendez-Roldan, S., Giacometti, A., Morf, A. and Isaksson, I., 2021. International good practices for facilitating transboundary collaboration in Marine Spatial Planning. *Marine Policy, 132*, p.103492.

Legge, O., Johnson, M., Hicks, N., Jickells, T., Diesing, M., Aldridge, J., Andrews, J., Artioli, Y., Bakker, D.C., Burrows, M.T. and Carr, N., 2020. Carbon on the northwest European shelf: Contemporary budget and future influences. *Frontiers in Marine Science, 7*, p.143.

Maes, T., Barry, J., Leslie, H.A., Vethaak, A.D., Nicolaus, E.E.M., Law, R.J., Lyons, B.P., Martinez, R., Harley, B. and Thain, J.E., 2018. Below the surface: Twenty-five years of seafloor litter monitoring in coastal seas of North West Europe (1992–2017). *Science of The Total Environment, 630*, pp.790-798.

Martin, J., Lusher, A., Thompson, R.C. and Morley, A., 2017. The deposition and accumulation of microplastics in marine sediments and bottom water from the Irish continental shelf. *Scientific Reports, 7*(1), pp.1-9.

Mitchell, I., Daunt, F., Frederiksen, M. and Wade, K., 2020, Impacts of climate change on seabirds, relevant to the coastal and marine environment around the UK.

Mcleod, E., Chmura, G.L., Bouillon, S., Salm, R., Björk, M., Duarte, C.M., Lovelock, C.E., Schlesinger, W.H. and Silliman, B.R., 2011. A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO_2. Front Ecol Environ 2011; 9(10), pp. 0552–560

MMO, 2019, Section 2: Landings, National Statistics: UK sea fisheries annual statistics report 2019, **https://www.gov.uk/government/statistics/uk-sea-fisheries-annual-statistics-report-2019**

National Research Council, 2003. Ocean Noise and Marine Mammals. *National Research Council (US) Committee on Potential Impacts of Ambient Noise in the Ocean on Marine Mammals*

Newell, R.C., Seiderer, L.J., Simpson, N.M., Robinson, J.E., 2004. Impacts of marine aggregate dredging on benthic macrofauna off the south coast of the United Kingdom. *Journal Coastal Research*, 20, 115–125.

Nicolaus, E.M., Wright, S.R., Bolam, T.P., Barber, J.L., Bignell, J.P. and Lyons, B.P., 2016. Spatial and temporal analysis of the risks posed by polychlorinated biphenyl and metal contaminants in dab (Limanda limanda) collected from waters around England and Wales. *Marine Pollution Bulletin, 112*(1-2), pp.399-405.

Nisra, 2019, Tourism Statistics Annual Publication 2019, **https://www.nisra.gov.uk/sites/nisra.gov.uk/files/publications/Tourism-Statistics-Annual-Publication-2019_0.pdf**

Neo, Y.Y., Seitz, J., Kastelein, R.A., Winter, H.V., Ten Cate, C. and Slabbekoorn, H., 2014. Temporal structure of sound affects behavioural recovery from noise impact in European seabass. *Biological Conservation, 178*, pp.65-73.

Nowacek, D.P., Thorne, L.H., Johnston, D.W. and Tyack, P.L., 2007. Responses of cetaceans to anthropogenic noise. *Mammal Review, 37*(2), pp.81-115.

O'Higgins, T., O'Higgins, L., O'Hagan, A.M. and Ansong, J.O., 2019. Challenges and opportunities for ecosystem-based management and marine spatial planning in the Irish Sea. In *Maritime spatial planning* (pp. 47-69).

O'Neill, R. 2017. The distribution of the European sea bass, Dicentrarchus labrax, in Irish waters. PhD Thesis, University College Cork, **https://cora.ucc.ie/bitstream/handle/10468/5127/ONeillRP_PhD2017.pdf?sequence=1**

O'shaughnessy, K.A., Hawkins, S.J., Yunnie, A.L., Hanley, M.E., Lunt, P., Thompson, R.C. and Firth, L.B., 2020. Occurrence and assemblage composition of intertidal non-native species may be influenced by shipping patterns and artificial structures. *Marine Pollution Bulletin, 154*, p.111082

Putland, R.L., Merchant, N.D., Farcas, A. and Radford, C.A., 2018. Vessel noise cuts down communication space for vocalizing fish and marine mammals. *Global change biology, 24*(4), pp.1708-1721.

Reubens, J.T., Degraer, S. and Vincx, M., 2014. The ecology of benthopelagic fishes at offshore wind farms: a synthesis of 4 years of research. *Hydrobiologia, 727*(1), pp.121-136

Reed, M., Courtney, P., Urquhart, J. and Ross, N., 2013. Beyond fish as commodities: Understanding the socio-cultural role of inshore fisheries in England. *Marine Policy, 37*, pp.62-68.

Rice, M. A. 2008. Environmental Effects of Shellfish Aquaculture in the Northeast. NRAC Publication: 6 pp. **http://seagrant.uconn.edu/whatwedo/aquaculture/pdf/nrac105- environeff.pdf**

Richir, J., Bray, S., McAleese, T. and Watson, G.J., 2021. Three decades of trace element sediment contamination: the mining of governmental databases and the need to address hidden sources for clean and healthy seas. *Environment International, 149*, p.106362.

Sala, E., Mayorga, J., Bradley, D., Cabral, R.B., Atwood, T.B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander, A.M. and Gaines, S.D., 2021. Protecting the global ocean for biodiversity, food and climate. *Nature, 592*(7854), pp.397-402.

Santillo, D., Brigden, K., Pasteur, V., Nicholls, F., Morozzo, P. and Johnston, P., 2019. Plastic pollution in UK's rivers: a 'snapshot'survey of macro-and micro-plastic contamination in surface waters of 13 river systems across England, Wales, Scotland and Northern Ireland. *Wales, Scotland and Northern Ireland| Technical Report*, pp.4-2019.

Scott, A.P., Sanders, M., Stentiford, G.D., Reese, R.A. and Katsiadaki, I., 2007. Evidence for estrogenic endocrine disruption in an offshore flatfish, the dab (Limanda limanda L.). *Marine environmental research, 64*(2), pp.128-148.

Scott, K., Harsanyi, P. and Lyndon, A.R., 2018. Baseline measurements of physiological and behavioural stress markers in the commercially important decapod Cancer pagurus (L.). *Journal of Experimental Marine Biology and Ecology, 507*, pp.1-7.

Smart, L.S., Vukomanovic, J., Sills, E.O. and Sanchez, G., 2021, Cultural ecosystem services caught in a 'coastal squeeze' between sea level rise and urban expansion. *Global Environmental Change, 66*, p.102209.

Simpson, M., 2013, Impacts of climate change on tourism (and marine recreation), MCCIP *Science Review* 2013, 271- 283, doi:10.14465/2013.arc29.271-283

Smith, P.J., Francis, R.I.C.C. and McVeagh, M., 1991. Loss of genetic diversity due to fishing pressure. *Fisheries Research*, 10(3-4), pp.309-316.

Stafford, R., Ashley, M., Clavey, L., Estevens, L.S., Hicks, N., Jones, A., Leonard, P., Luisetti, T., Martin, A., Parker, R., Rees, S., Schratzberger, M., and Unsworth, R. 2021. Coastal and Marine Ecosystems. Nature-based Solutions for Climate Change in the UK: A Report by the British Ecological Society. London, UK., pp.107-190. Available at: **https://www.britishecologicalsociety.org/policy/naturebased-solutions/read-the-report/**

Stanley, J.A., Van Parijs, S.M. and Hatch, L.T., 2017. Underwater sound from vessel traffic reduces the effective communication range in Atlantic cod and haddock. *Scientific reports, 7*(1), pp.1-12.

Statistica, 2021, Number of visits to the Giant's Causeway in Northern Ireland from 2014 to 2021, **https://www.statista.com/statistics/1143369/giant-s-causeway-visitor-numbers-northern-ireland/**, last accessed 5/05/2022

Stewart, B.D., Howarth, L.M., Wood, H., Whiteside, K., Carney, W., Crimmins, É., O'Leary, B.C., Hawkins, J.P. and Roberts, C.M., 2020. Marine conservation begins at home: how a local community and protection of a small bay sent waves of change around the UK and beyond. *Frontiers in Marine Science, 7*, p.76.

Swift, D.J., 1993. The macrobenthic infauna off Sellafield (north-eastern Irish Sea) with special reference to bioturbation. *Journal of the Marine Biological Association of the United Kingdom*, 73: 143-162

Tett, P, Benjamins, S, Black, K, Coulson, M, Davidson, K, Fernandes, TF, Fox, C, Hart, M, Hicks, N, Hughes, A, Hunter, DC, Nickell, T, Risch, D, Tocher, D, Vare, L, Verspoor, E, Wilding, T, Wilson, B & Wittich, A 2018, *Review of the environmental impacts of salmon farming in Scotland*. **http://www.parliament.scot/parliamentarybusiness/CurrentCommittees/107588.aspx**

The Crown Estate, 2018, Marine aggregate dredging 1998-2017 a twenty-year review, **https://www.thecrownestate.co.uk/media/2870/marine-aggregate-dredging-1998-2017-a-twenty-year-review.pdf**

Thurstan, R.H., Brockington, S. and Roberts, C.M., 2010. The effects of 118 years of industrial fishing on UK bottom trawl fisheries. *Nature communications, 1*(1), pp.1-6.

Tillin, H, Tyler-Walters, H., 2013, Assessing the sensitivity of subtidal sedimentary habitats to pressures associated with marine activities. Phase 1 Report: Rationale and proposed ecological groupings for Level 5 biotopes against which sensitivity assessments would be best undertaken, JNCC Report No. 512A **http://jncc.defra.gov.uk/pdf/Report%20512-A_phase1_web.pdf**

Tougaard, J., Carstensen, J., Teilmann, J., Skov, H. and Rasmussen, P., 2009. Pile driving zone of responsiveness extends beyond 20 km for harbor porpoises (Phocoena phocoena (L.)). *The Journal of the Acoustical Society of America, 126*(1), pp.11-14.

Turnbull, J., Johnston, E., Clark, F., 2021, Evaluating the social and ecological effectiveness of partially protected marine areas. Conservation Biology, DOI: **10.1111/cobi.13677**

Turner, S.J., Thrush, S.F., Hewitt, J.E., Cummings, V.J. and Funnell, G., 1999. Fishing impacts and the degradation or loss of habitat structure. *Fisheries Management and Ecology, 6*(5), pp.401-420.

UK Centre for Ecology and Hydrology (UKCEH), 2020, Impacts of climate change on UK coasts and seas are highlighted **https://www.ceh.ac.uk/news-and-media/news/impacts-climate-change-uk-coasts-and-seas-highlighted, accessed 27.7.2021**

van der Kooij, J., Campanella, F., Rodríguez Climent, S., (2021). Pressures on forage fish in Welsh Waters. Cefas Project Report for RSPB, 35 pp.

Vincent, M.A., Atkins, S.M., Lumb, C.M., Golding, N., Lieberknecht, L.M. and Webster, M. (2004). *Marine nature conservation and sustainable development – the Irish Sea Pilot*. Report to Defra by the Joint Nature Conservation Committee, Peterborough.

VisitBritain, 2019, GB Day Visits Survey: Latest Results, **https://www.visitbritain.org/gb-day-visits-survey-latest-results**

Visit Scotland, 2021, Seas the Day! Exploring the appeal of Scotland's coastal destinations for visitor, **https://www.visitscotland.org/binaries/content/assets/dot-org/pdf/research-papers/about-our-visitors/coastal-tourism-june-2021.pdf**

Welsh National Marine Plan, 2019, **https://gov.wales/sites/default/files/publications/2019-11/welsh-national-marine-plan-document_0.pdf**

Waye-Barker, G. A., McIlwaine, P., Lozach, S., and Cooper, K. M. 2015. The effects of marine sand and gravel extraction on the sediment composition and macrofaunal community of a commercial dredging site (15 years post-dredging). *Marine Pollution Bulletin*, 99: 207–215. **https://doi.org/10.1016/j.marpolbul.2015.07.024**

Weilgart, L., 2018. The Impact of Ocean Noise Pollution on Fish and Invertebrates. Report for OceanCare, Switzerland. **https://www.oceancare.org/wp-content/uploads/2017/10/OceanNoise_FishInvertebrates_May2018.pdf**

Wisniewska, D.M., Johnson, M., Teilmann, J., Siebert, U., Galatius, A., Dietz, R. and Madsen, P.T., 2018. High rates of vessel noise disrupt foraging in wild harbour porpoises (Phocoena phocoena). *Proceedings of the Royal Society B: Biological Sciences, 285*(1872), p.20172314.

Wilhelmsson, D., Malm, T. and Öhman, M.C., 2006. The influence of offshore windpower on demersal fish. *ICES Journal of Marine Science, 63*(5), pp.775-784.

Wysocki, L.E., Dittami, J.P. and Ladich, F., 2006. Ship noise and cortisol secretion in European freshwater fishes. *Biological conservation, 128*(4), pp.501-508.

The Irish Sea Network

Appendix

Appendix 1 Government bodies and statutory agencies working around the Irish Sea

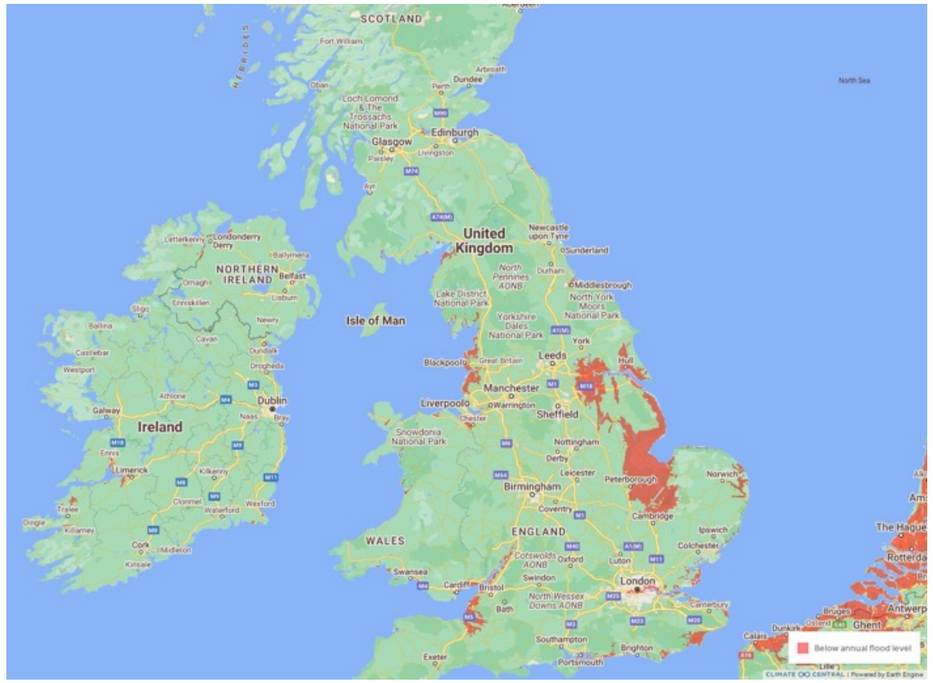
Region	Name	Role/description
England	**Department for Environment, Food and Rural Affairs (Defra)**	Government department responsible for marine environmental protection, and fisheries in English waters.
	Marine Management Organisation (MMO)	Executive non-departmental public body, acts as the marine planning authority on behalf of UK Government, delivering marine functions in English territorial waters and UK offshore waters (for matters that are not devolved) such as marine licensing and enforcement of marine legislation.
	Inshore Fisheries and Conservation Authorities (IFCAs)	10 regional IFCAs around the coast of England, with a purpose to lead, champion and manage a sustainable marine environment and inshore fisheries, by balancing social, environmental and economic benefits to ensure healthy seas, sustainable fisheries and a viable industry.
	Natural England	Statutory nature conservation body (SNCB) on nature conservation out to 12 nm in English Waters and the lead on advice on offshore wind.
England, Northern Ireland, Wales	**Joint Nature Conservation Committee (JNCC)**	Advises UK Government and devolved administrations on UK-wide and international nature conservation. JNCC has responsibility for the provision of nature conservation advice in the offshore area
	The Crown Estate	Own and leases the seabed out to the 12 nm territorial limit and manages about half of the foreshore. Lease sites for offshore energy resources, provide licenses for mineral mining and dredging, provide rights for cables and pipelines, manages about half of the foreshore.
Isle of Man	**Department of Environment, Food and Agriculture (DEFA)**	Government department responsible for fisheries and marine conservation.
	Department of Infrastructure (DOI)	Government department responsible for Infrastructure, such as harbours, and owner of the seabed.
	NGO advisors	Manx Wildlife Trust, Manx Whale and Dolphin Watch, Manx Basking shark Watch, Manx BirdLife all advise government at times
Northern Ireland	**Department of Agriculture, Environment and Rural Affairs (DAERA)**	Government department where the Marine and Fisheries Division sits.
	Inshore Fisheries Partnership Group	Stakeholder group facilitated by DAERA participating in management decisions and promoting the long-term sustainability of inshore fisheries (non-quota species i.e. all shellfish excluding *Nephrops*).

Region	Name	Role/description
Northern Ireland (continued)	Northern Ireland Environment Agency (NIEA)	Executive agency within DAERA responsible for the conservation of Northern Irelands environment and natural heritage.
	Council for Nature Conservation and the Countryside (CNCC)	a SNCB, The CNCC has a Marine and Coastal Working Group who advise DAERA on matters relating to nature conservation
Northern Ireland, Republic of Ireland	The Loughs Agency	Manages fisheries in Lough Foyle and Carlingford Lough – both at the land border of Northern Ireland and the Republic of Ireland, known as 'shared water bodies'.
Republic of Ireland	Department of Housing, Local Government and Heritage	The water Division in the department has responsibility for marine waters including bathing water quality, MSFD, shellfish waters and MPAs. This is in addition to private and public drinking water and wastewater services, water protection.
	National Parks and Wildlife Service (NPWS)	Heritage Division of the Department of Housing, Local Government and Heritage. Management of Ireland's nature conservation responsibilities (e.g. SPAs, SACs and Natural Heritage Areas).
	Department of Agriculture, Food and the Marine	Sea-Fisheries Policy & Management Division is responsible for the strategic, economic and sustainable development of the seafood sector, as well as the broad regulation of it, within the framework of the Common Fisheries Policy, the Sea-fisheries and Maritime Jurisdiction Act 2006 and the Fisheries (Amendment) Act 2003.
	Department of the Environment, Climate and Communications	This government department has the responsibility for climate action and the environment, communications and digital, energy and natural resources.
	Bord Iascaigh Mhara (Irish Sea Fisheries Board) (BIM)	State Agency, BIM works to support and enable an increase in value creation of a sustainable Irish seafood sector across the supply chain, from catch to consumer.
	Environmental Protection agency (EPA)	Independent public body which holds a wide range of functions to protect the environment. Primary responsibilities include for example; environmental licensing, enforcement of environmental law, monitoring, analysing and reporting on the environment etc.
	Inland Fisheries Ireland (IFI)	State agency responsible for the conservation, protection, management, marketing, development and improvement of inland fisheries and sea angling resources.
	Marine Institute	State agency responsible for the conservation, protection, management, marketing, development and improvement of inland fisheries and sea angling resources.
	Sea Fisheries Protection Agency (SFPA)	The SFPA is the independent statutory body responsible for the regulation of the sea-fisheries and the seafood production sectors. SFPA promotes compliance with the EU Common Fisheries Policy, sea-fisheries law and food safety law relating to fish and fish products, verify compliance and, where necessary, enforce it.

The Irish Sea Network

Region	Name	Role/description
Scotland	Marine Scotland	Government body responsible for integrated management of Scotland's seas, working closely with delivery partners NatureScot and the SEPA (see below). Teams within Marine Scotland: Licensing of marine activity, Sea fisheries, Salmon farming and recreational fisheries, Marine renewable energy, Marine conservation, Marine spatial planning, Scientific research including sea and freshwater fisheries, Enforcement of marine and fisheries law.
	NatureScot	The government's statutory adviser on Scotland's natural heritage.
	Scottish Environment Protection Agency	The principle environmental regulator and a Non-departmental public body of the Scottish Government.
	Crown Estate Scotland	A statutory consultee that holds the rights to offshore wind and carbon and gas storage (out to 200 nm). Owner of most of Scotland's coastline and leasing of the seabed out to 12 nm. Areas of interest: Salmon farming, Offshore wind development, Seaweed harvesting, Telecommunication and electricity cables, Oil and gas pipelines, Ports and harbours.
Wales	Natural Resources Wales (NRW)	A SNCB to the Welsh Government for the Welsh inshore region (0-12 nm) and offshore.
	Welsh Government	Has overall responsibility for Wales' compliance with EU and international obligations towards MPAs in the Welsh inshore region (0-12 nm) and offshore and the designation of MPAs (excluding SSSIs).
	Local Authorities	Are the landowners (some areas of foreshore) and provide management of (non-permissible) development (down to the Low Water Mark) and management of recreation activities (within their area of geographical and organisational responsibility).
	Fisheries Local Action Groups (FLAG)	Partnerships funded by Welsh Government & European Maritime and Fisheries Fund. It seems to be that these are the equivalent/similar to IFCAs. 4 FLAG regions in Wales.

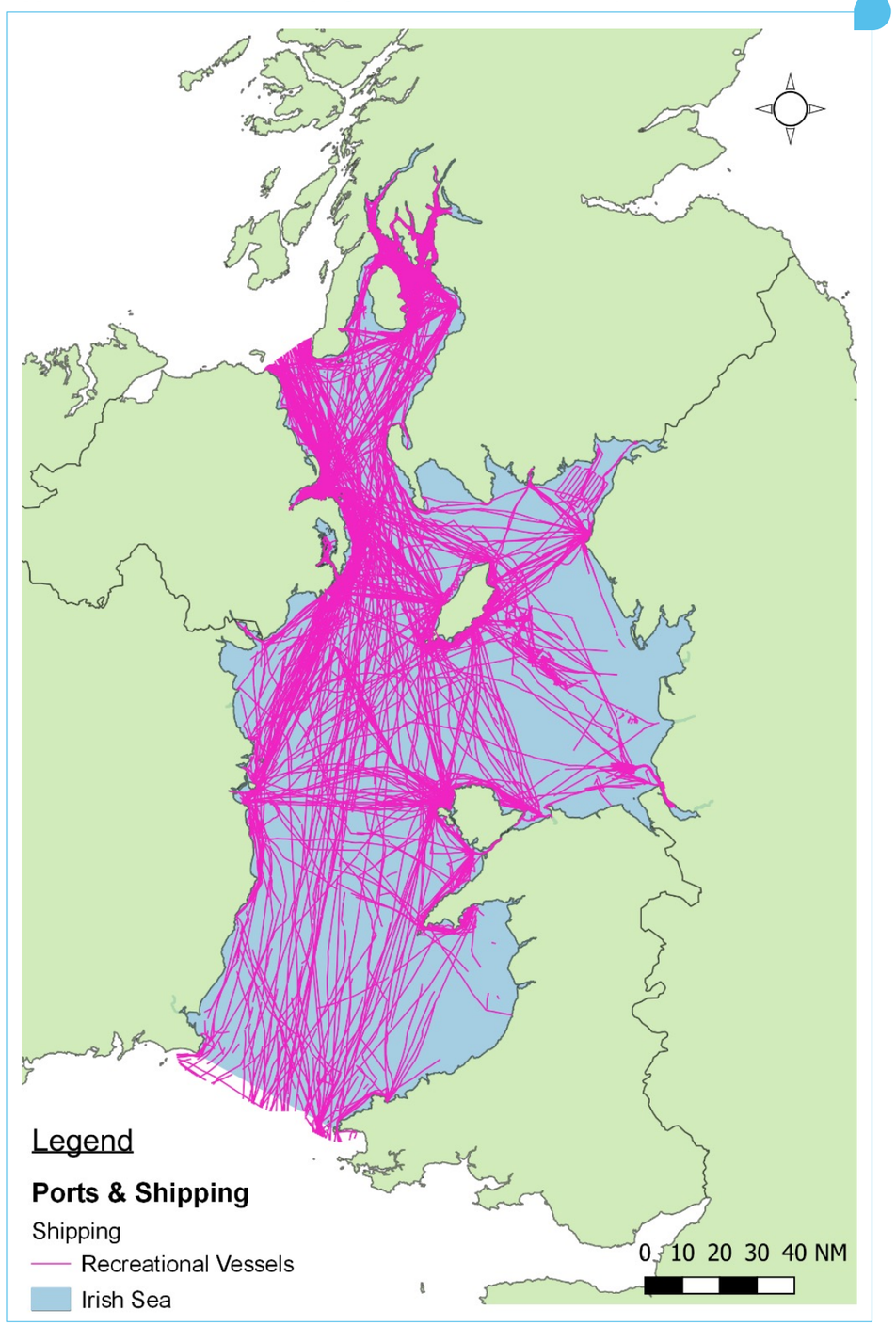
Appendix 2: *Climate Central, LAND PROJECTED TO BE BELOW ANNUAL FLOOD LEVEL IN 2050,* **https://coastal.climatecentral.org/map/7/3.6779/54.1891/?theme=sea_level_rise&map_type=year&basemap=roadmap&contiguous=true&elevation_model=best_available&forecast_year=2050&pathway=ssp3rcp70&percentile=p50&refresh=true&return_level=r, last accessed 20/4/22**



Appendix 3: *Data sources for Figure 5, Activities in the Irish Sea.*

Pressures	England	Wales	Scotland	Northern Ireland	Republic of Ireland	Isle of Man
Fishing	OSPAR	OSPAR	OSPAR	OSPAR	OSPAR	OSPAR
Aquaculture	**EMODnet**	EMODnet	Aquaculture – Finfish and shellfish farms (including fishery sites) – data.gov.uk	Aquaculture Licences – Open Data – Datasets – Open Data NI	EMODnet	EMODnet
Military Activity		Approximate using https://www.milfordmarina.com/	Used Coordinates NMPI			
Renewable Energy	Crown Estate	Crown Estate	Used Coordinates NMPI	Used Coordinates	Used Coordinates	
Oil and Gas	**https://data-ogauthority.opendata.arcgis.com**	https://data-ogauthority.opendata.arcgis.com	https://data-ogauthority.opendata.arcgis.com	https://data-ogauthority.opendata.arcgis.com	https://data-ogauthority.opendata.arcgis.com	
Navigation/ Shipping	MMO – AIS data 2015	MMO – AIS data 2015	MMO – AIS data 2015	MMO – AIS data 2015	MMO – AIS data 2015	MMO – AIS data 2015
Ports	EMODnet	EMODnet	EMODnet	EMODnet	EMODnet	EMODnet
Cables	Crown Estate	Crown Estate	EMODnet	EMODnet	EMODnet	EMODnet
Disposal site (dredging)	CEFAS	CEFAS	CEFAS	CEFAS	EMODnet	EMODnet

Appendix 4: *Recreational shipping in the Irish Sea, AIS data from 2015, MMO*



Appendix 5: *Marine Protected Areas in the Irish Sea and their level of protection. Used to inform Figure 7. Engl. = England; Scot. = Scotland; ROI = Republic of Ireland; IOM = Isle of Man; N. Irl. = Northern Ireland; MCZ = Marine Conservation Zone; SPA = Special Protection Area; SAC = Special Area of Conservation; MNR = Marine Nature Reserve; IFCA = Inshore Fisheries and Conservation Authority*

Country	Name	Type	Level of Protection	Notes
England	Cumbria coast zone 1	MCZ	No management	
England	Cumbria coast zone 2	MCZ	No management	
England	Wyre-Lune	MCZ	No management	
England	West of Walney	MCZ	No management	
England	Allonby Bay	MCZ	No management	
England	West of Copeland	MCZ	No management	
England	Ribble Estuary	MCZ	No management	
England	Fylde	MCZ	No management	
England	Morecambe Bay and Duddon Esturary	SPA	No management	
England	Ribble and Alt Estuaries	SPA	No management	
England	Mersey Estuary	SPA	No management	
England	Morecambe Bay	SAC	No management	
England	Drigg Coast	SAC	No management	
England	Shell Flat and Lune Deep	SAC	No management	
England	The Solway Firth EMS Sabellaria alveolata reef closed area;	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear
England	The Morecambe Bay EMS Seagrass beds closed areas;	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear and hand gathering of sea fisheries resources
England	The Morecambe Bay EMS Walney Channel boulder and cobble reef closed area;	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear
England	The Morecambe Bay EMS Walney Channel boulder and cobble reef closed area;	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear
England	The Morecambe Bay EMS Walney Channel boulder and cobble reef closed area;	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear

The Irish Sea Network

Country	Name	Type	Level of Protection	Notes
England	The Dee Estuary EMS Hilbre Island Sabellaria alveolata reef closed area; and	IFCA Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear
England	St Bees Voluntary Ban on netting		Lightly or minimally protected	Voluntary Ban on placing nets around St Bees
England	NWIFCA Bylaw 3 Mussles & Cockles	IFCA Bylaw	Lightly or minimally protected	Ban on gathering cockles or mussels without a gathering permit.
England	West of Walney MMO Bylaw	MMO Bylaw	Lightly or minimally protected	Ban on bottom towed fishing gear
England/Scotland	Solway Firth	MCZ	No management	
England/Scotland	Upper Solway Flats and Marshes – Solway Firth	SPA	No management	
England/Scotland	Solway Firth	SAC	No management	
England/ Wales	Liverpool Bay	SPA	No management	
England/ Wales	Dee Estuary	SPA	No management	
England/ Wales	Dee Estuary/Aber Dyfrdwy	SAC	No management	
Isle of Man	Baie ny Carrickey MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Douglas Bay MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Langness MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Laxey Bay MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Little Ness MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Niarbyl Bay MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Port Erin Bay MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	Ramsey Bay MNR	MNR	Lightly or minimally protected	5 different zones with differing management/ protection

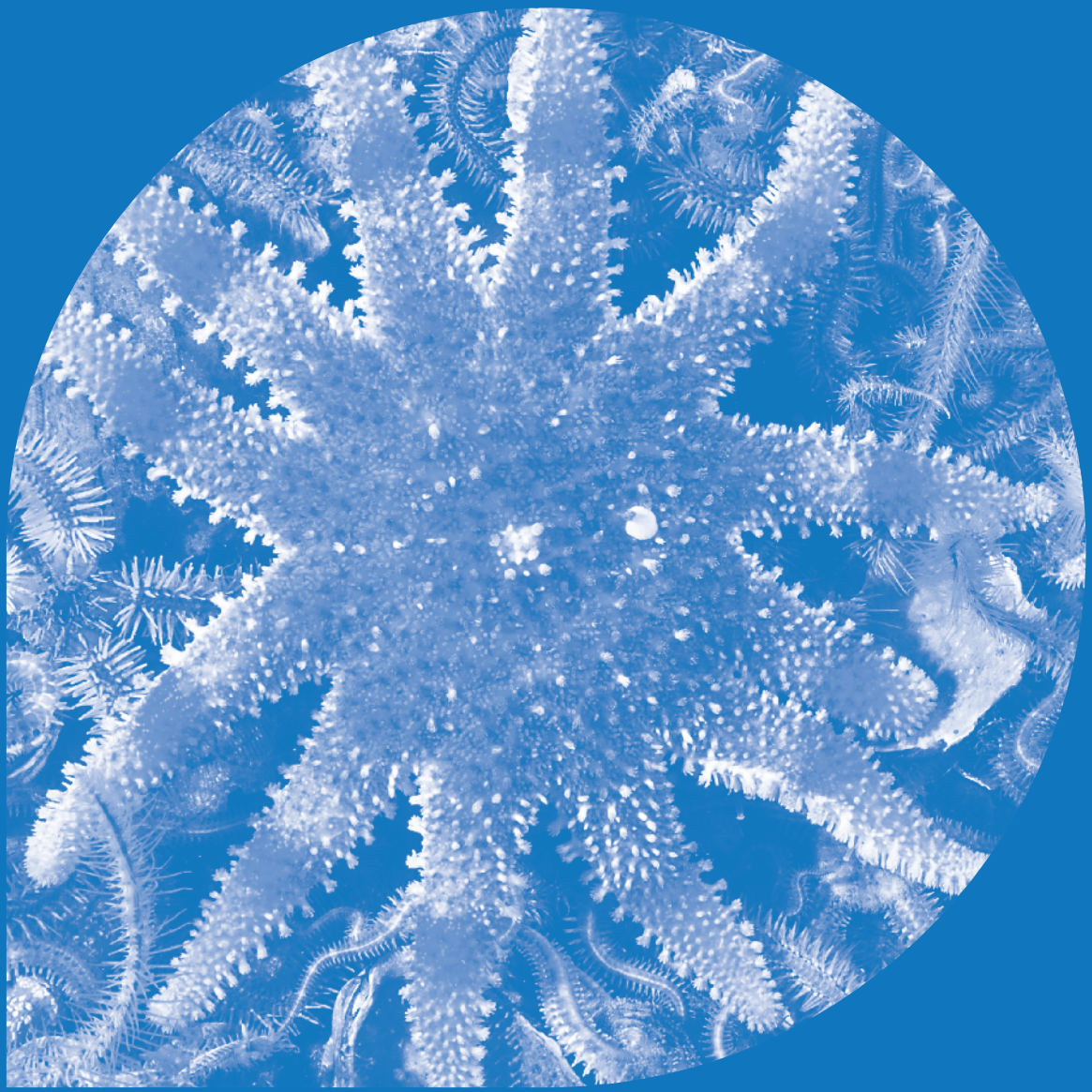
Country	Name	Type	Level of Protection	Notes
Isle of Man	Calf and Wart Bank MNR	MNR	Lightly or minimally protected	Protected from mobile gear
Isle of Man	West Coast MNR	MNR	Lightly or minimally protected	Protected from mobile gear
N. Ireland	Pisces Reef Complex	SAC	No management	
N. Ireland	Murlough	SAC	No management	
N. Ireland	North Channel	SAC	No management	
N. Ireland	Luce Bay and Sounds	SAC	No management	
N. Ireland	The Maidens	SAC	No management	
N. Ireland	Strangford Lough	SAC	Fully or Lightly or minimally protected	Fully excluded from fishing, except a small path in the middle, to protect communities of Horse Mussel (Modiolus Modiolus) from sea fishing below 10m (does not include rod and line fishing)
N. Ireland	Strangford Lough	MCZ	No management	
N. Ireland	Carlingford Lough	MCZ	No management	
N. Ireland	South Rigg	MCZ	No management	
N. Ireland	Outer Belfast Lough	MCZ	No management	
N. Ireland	Waterfoot	MCZ	No management	
N. Ireland	Carlingford Lough	SPA	No management	
N. Ireland	Strangford Lough	SPA	No management	
N. Ireland	Outer Ards	SPA	No management	
N. Ireland	Belfast Lough Open Water	SPA	No management	
N. Ireland	Larne Lough	SPA	No management	
N. Irel./Engl.	Queenie Corner	MCZ	No management	
Rep. of Ireland	Rockabill to Dalkey Island SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Carlingford Lough SAC	SAC	No management	
Rep. of Ireland	Dundalk Bay SAC	SAC	No management	
Rep. of Ireland	Boyne Coast And Estuary SAC	SAC	No management	

Country	Name	Type	Level of Protection	Notes
Rep. of Ireland	Rogerstown Estuary SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Malahide Estuary SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Baldoyle Bay SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	North Dublin Bay SAC	SAC	No management	
Rep. of Ireland	South Dublin Bay SAC	SAC	No management	
Rep. of Ireland	Codling Fault Zone SAC	SAC	No management	
Rep. of Ireland	Bray Head SAC	SAC	No management	
Rep. of Ireland	The Murrough Wetlands SAC	SAC	No management	
Rep. of Ireland	Wicklow Reef SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Buckroney-Brittas Dunes And Fen SAC	SAC	No management	
Rep. of Ireland	Blackwater Bank SAC	SAC	No management	
Rep. of Ireland	Slaney River Valley SAC	SAC	No management	
Rep. of Ireland	Carnsore Point SAC	SAC	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Clogher Head	SAC	No management	
Rep. of Ireland	Lambay Island	SAC	No management	
Rep. of Ireland	Ireland's Eye	SAC	No Management	
Rep. of Ireland	Howth Head Coast	SAC	No management	

Country	Name	Type	Level of Protection	Notes
Rep. of Ireland	Dundalk Bay SPA	SPA	No management	
Rep. of Ireland	Rockabill SPA	SPA	No management	
Rep. of Ireland	Boyne Estuary SPA	SPA	No management	
Rep. of Ireland	River Nanny Estuary and Shore SPA	SPA	No management	
Rep. of Ireland	Skerries Islands SPA	SPA	No management	
Rep. of Ireland	Lambay Island SPA	SPA	No management	VERY limited fisheries management measures however, these are not part of an overall site management plan, other dredging fisheries take place in these sites
Rep. of Ireland	Rogerstown Estuary SPA	SPA	No management	
Rep. of Ireland	Malahide Estuary SPA	SPA	No management	
Rep. of Ireland	Baldoyle Bay SPA	SPA	No management	
Rep. of Ireland	Ireland's Eye SPA	SPA	No management	
Rep. of Ireland	Howth Head Coast SPA	SPA	No management	
Rep. of Ireland	North Bull Island SPA	SPA	No management	
Rep. of Ireland	Dalkey Islands SPA	SPA	No management	
Rep. of Ireland	The Murrough SPA	SPA	No management	
Rep. of Ireland	Wicklow Head SPA	SPA	No management	
Rep. of Ireland	Cahore Marshes SPA	SPA	No management	
Rep. of Ireland	The Raven SPA	SPA	No management	
Rep. of Ireland	Wexford Harbour and Slobs SPA	SPA	No management	
Rep. of Ireland	Long Bank SAC	SAC	No management	
Rep. of Ireland	Skerries Islands NHA	National Heritage Site	No management	
Rep. of Ireland	South Dublin Bay and River Tolka Estuary	SPA	No management	
Rep. of Ireland	Magherabeg Dunes	SAC	No management	
Rep. of Ireland	Kilpatrick Sandhills	SAC	No management	

The Irish Sea Network

Country	Name	Type	Level of Protection	Notes
Rep. of Ireland	Cahore Polders and Dunes	SAC	No management	
Rep. of Ireland	Kilmuckridge-Tinnaberna Sandhills	SAC	No management	
Rep. of Ireland	Raven Point Nature Reserve	SAC	No management	
Scotland	Ailsa Craig	SPA	No management	
Scotland	Clyde Sea Sill	MPA	No management	
Scotland	South Arran	MPA	Lightly or minimally protected	Designated in 2014
Scotland	Lamlash Bay	No-Take Zone	Fully protected	All extractive activities banned in Lamlash Bay only
Wales	Irish Sea front	SPA	No management	
Wales	Anglesey Terns / Morwenoliaid Ynys Môn	SPA	No management	
Wales	Glannau Aberdaron ac Ynys Enlli / Aberdaron Coast and Bardsey Island	SPA	No management	
Wales	Northern Cardigan Bay / Gogledd Bae Ceredigion	SPA	No management	
Wales	Dyfi Estuary / Aber Dyfi	SPA	No management	
Wales	Y Fenai a Bae Conwy / Menai Strait and Conwy Bay	SAC	No management	
Wales	North Anglesey Marine / Gogledd Môn Forol	SAC	No management	
Wales	Croker Carbonate Slabs	SAC	No management	
Wales	Pen Llyn a`r Sarnau/ Lleyn Peninsula and the Sarnau	SAC	Lightly or minimally protected	1FTE SAC Officer (http://penllynarsarnau.co.uk/management_plan.html)
Wales	West Wales Marine / Gorllewin Cymru Forol	SAC	No management	



Acknowledgments
This report was compiled by Georgia de Jong Cleyndert with contributions from Emily Baxter, Bernadette Butfield, Beth Churn, Sam Collin, Lara Howe, Nia Jones, Ellen MacMahon, Heidi McIlvenny, Lisa Morgan and Sarah Perry. The Irish Sea Network has been supported by Lucent Consultancy and has been funded by Esmée Fairbairn and John Ellerman Foundation.
http://www.irishseanetwork.org ISBN 978-1-3999-3641-5

Registered in England as Cumbria Wildlife Trust Limited, a Company Limited by Guarantee No. 00724133. Registered Charity No. 218711.