39. Western Irish Sea Front

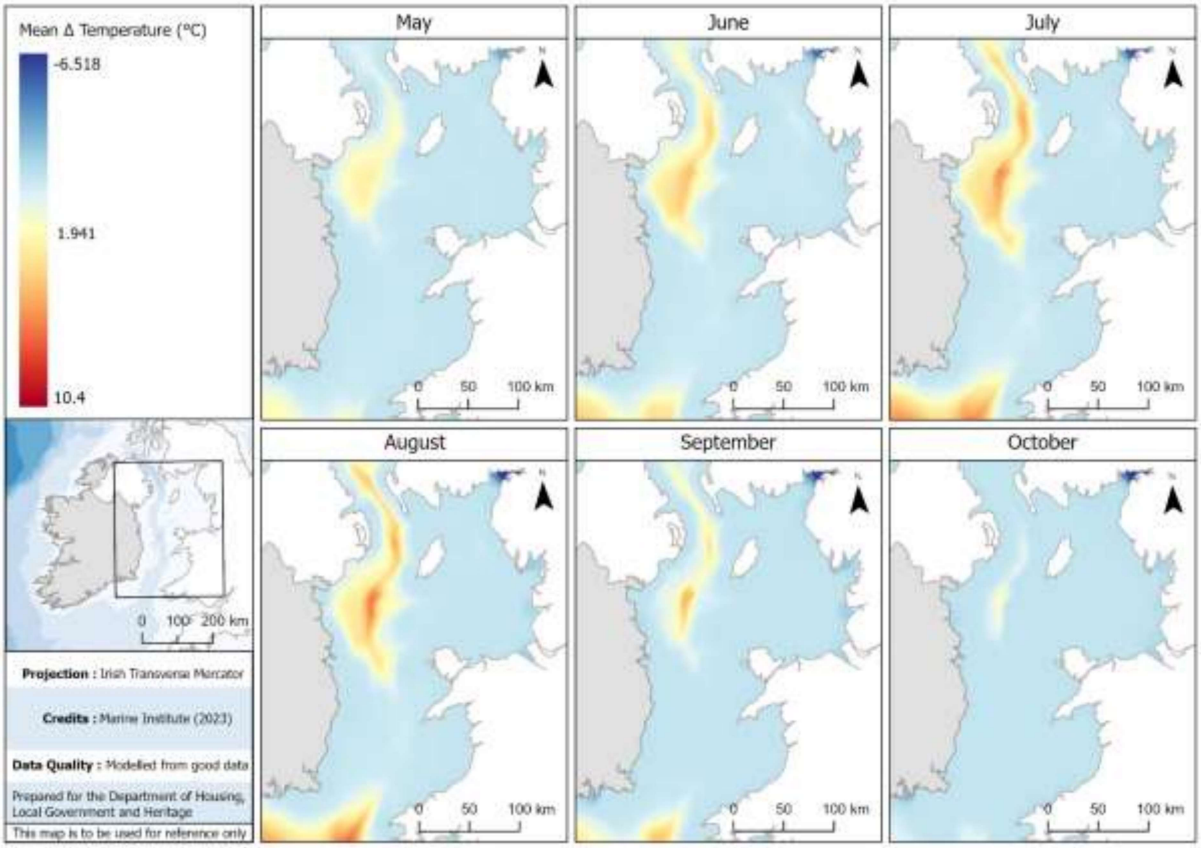

Figure 1: Satellite image of mean sea surface temperature (SST) change in the western Irish Sea, which shows the presence of the Western Irish Sea Front along the southern boundary of the warm stratified water © Marine Institute (2023).

Background

Physical characteristics

The Western Irish Sea Front marks a boundary between tidally mixed and stratified bodies of water in the Irish Sea during the spring and summer months (Hill et al., 1997; Simpson et al., 2009; Simpson and Hunter, 1974). The area between the Irish northeast coast and the Isle of Man is the deepest section of the Irish Sea and thus, where tidal energy becomes relatively weak. As a result, surface heating in the spring and summer leads to warming of the surface waters and a stabilization or stratification of the water column (Simpson and Hunter, 1974). Through May, June, and July the heating of the surface continues and the temperature difference between the stratified and mixed water can exceed 3° C (Simpson and Hunter, 1974). The horizontal temperature gradients extend downward to some extent and lead to the creation of the seasonal near surface gyre, which effectively becomes an isolated body of water with minimal exchange between adjacent mixed water (Hill et al., 1997; Simpson et al., 2009). As the thermal stratification intensifies at the surface, a residual cold dome of water is retained beneath which drives a lateral flow (baroclinic flow) across the front (Hill et al., 1997). The position of the front does not vary to any great degree from year to year and its presence is readily detectable due to pronounced changes in the colour of the sea, and

aggregations of neuston due to convergent flows near the surface (Simpson and Hunter, 1974).

Ecological significance

The presence of the Western Irish Sea Front is ecologically significant, with important implication of organisms at all levels of the pelagic ecosystem. Frontal systems similar to the Western Irish Sea Front can form a distinct boundary between phytoplankton and zooplankton assemblages, enhance primary productivity, physically aggregate plankton, provide enhanced foraging for planktivorous fauna, which in turn provides enhanced foraging for large megafauna (seabirds, mammals, large fish, and sharks) (Acha et al., 2015; Cox et al., 2018; Davenport and Rees, 1993; Le Fevre, 1987; Scales et al., 2014).

Some studies in the past have indicated relatively high primary productivity at the Western Irish Sea Front (Richardson et al., 1985), however, more recent work suggests that anthropogenic nutrients are a controlling influence over primary productivity (Allen et al., 1998). These measurements were carried out repeatedly while stratification was present in a single season and indicate persistent higher values at the front (Richardson et al., 1985). Aggregations of neuston, including seaweed and associated larval fish species were found associated with fronts in the Irish Sea (Davenport and Rees, 1993). Larval fish in their first year, planktonic nephrops, and large zooplankton are found in high concentrations within the in the stratified water of the western Irish Sea (Dickey-Collas et al., 1996; Gowen et al., 1998; Hill et al., 1996), and the gyre provides a mechanism by which they are entrained and retained within the gyre (Dickey-Collas et al., 1996). These are all prey species for large fauna and the convergent flows at a front provide a mechanism which can aggregate and make these prey more available. Direct evidence of this is lacking, however, multiple seabirds forage along the western Irish Sea Front, periodically moving to maintain their position on the front (Dean et al., 2013; Durazo et al., 1998). The use of satellite tracking has demonstrated that Manx shearwaters (*Puffinus puffinus*) forge at the western Irish Sea Front and it has now been designated as an Special Protection Area (SPA) (JNCC, 2016). There is compelling and growing evidence that many frontal systems are important hot spots of pelagic biodiversity (Acha et al., 2015; Cox et al., 2018; Scales et al., 2014). Harbour porpoise use the Celtic Sea Front and respond to changes in the front position (Cox et al., 2018), indeed, the offshore migration of common dolphins is possibly linked to the seasonal breakdown of the Celtic Sea Front (Goold, 1998).

Rationale for spatial protection in the western Irish Sea

The Western Irish Sea Front is an area of ecological importance. Studies on seabirds have highlighted the importance of the area for forging and it likely that marine mammals, teleost fish and shark species also utilize the front (Cox et al., 2018; Scales et al., 2014).

The Western Irish Sea Front is not specifically protected by current legislation; however, protection of all pelagic habitats is laid down in the Marine Strategy Framework Directive (Directive 2008/56/EU). Several of the eleven qualitative descriptors in the MSFD relate to pelagic habitats and arguably support protection of frontal systems as a component of Good Environmental Status more generally in the Irish Sea.

Descriptor 1 - *Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.*

Descriptor 4 - *All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.*

Descriptor 7 – *Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.*

Descriptor 11 – *Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.*

The Western Irish Sea Front is amenable to spatial protection, which in turn also confers protection on a broad range of species which use the front. The Western Irish Sea Front is a predictable and seasonally persistent feature, which makes it amenable to spatial protection. There is also a precedent for protecting frontal systems; the Manx shearwaters SPA in the Irish Sea and the Pelagos Sanctuary in the Mediterranean Sea ("Pelagos Sanctuary official website," n.d.) explicitly target frontal systems and the species that use them. The Pelagos Sanctuary is also an example of transboundary management by three countries.

Sensitivity assessment

The western Irish Sea Front sensitivity assessment was based on the potential sensitivity of the front to the pressure 'changed water flow'. While other habitat assessments focused on characteristic species thought to be most sensitive, the range of species which use fronts is prohibitively large and varied and a species lead approach was therefore deemed unfeasible.

As such, this assessment was based on a literature review of all the relevant literature studying the impact of offshore wind turbines on local and regional hydrographic processes. There are two mechanisms relevant to wind farms that will create a wake. 1) Current flows flowing around infrastructure will create a wake effect, and 2) wind flow over and around an array of turbines and blades will create a wind shear that can generate vertical rotation in the water column, i.e., upwelling and downwelling (Ludewig, 2015). The individual wake created by each turbine may increase vertical mixing, scouring the seabed around structures, and resuspending sediments, i.e., increased turbidity (Carpenter et al., 2016; Lange et al., 2010; Ludewig, 2015). The turbulent wake is rapidly attenuated downstream of the turbine, becoming undetectable less than 1000 m downstream, although resuspended fine particulate matter may still be in suspension much further downstream. An assessment of a fixed bottom OWF off Germany, using hydrodynamic modelling, demonstrated no major impact of a monopile turbine on turbidity, nor was there a cumulative effect of multiple monopiles found (Lange et al., 2010).

Large turbine arrays will create wind shadows where the surface currents within and downstream of the array are reduced in speed, causing increases in surface temperatures, and thus intensifying stratification and altering thermocline depths (Christiansen et al., 2022). The changes in surface currents in turn changes the sea surface level, which creates large areas of upwelling and downwelling on the downstream side of the wind farm (Christiansen et al., 2022; Ludewig, 2015). While these changes are large in scale (>60 km), they are relatively small and within natural interannual variation (Christiansen et al., 2022), therefore, the potential sensitivity of the Western Irish Sea Front to these effects is assessed as low. However, this assessment should be kept under review as this area of research is relatively new and further research is needed.

Further research needs

While the sensitivity of frontal systems to wind farm created wakes is assessed as low, there is very little research on the potential impacts of increased sediment resuspension and turbidity due to ORE developments. Increased turbidity is recognised as a pressing ecological issue in recent years (Blain et al., 2021; Herbert-Read et al., 2022). Increasing wave energy, land use, and coastal eutrophication are causing increased turbidity in coastal regions globally and this has negative implications for fundamental ecological processes such as primary productivity and biogeochemical cycling. In the context of ORE developments, a large-scale reduction in bottom trawling will most likely reduce turbidity as trawling can re-suspend sediment and organic matter (Linders et al., 2018). Conversely, increased vertical mixing and upwelling because of multiple large wind farms may increase turbidity, however, this is purely speculative at this time. Research at existing wind farms can address some of these knowledge gaps with an increased focus on in situ sampling to inform better hydrodynamic modelling and prediction of environmental impacts. This means building collaborative research projects between Irish and European researchers to access these sites in other countries.

Data Sources

Dataset Name	Data Owning Organisation	Dataset Quality	Metadata URL	Comments
Marine Institute Oceanographic Models	Marine Institute	Modelled from good data		

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