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NWWAC advice on
The impact of Climate Change on fisheries in the North Western Waters
12 May 2021

1. Background

The European Commission's international governance agenda has identified climate change as a priority area for action by launching the European Green Deal in December 2019. The Green Deal provides a roadmap to make Europe climate neutral by 2050, through a just transition to a sustainable economy, decarbonizing industries, tackling pollution and restoring biodiversity. The role of oceans in mitigating and adapting to climate change is increasingly recognised in both the Green Deal and in the initiatives stemming from it, like the Biodiversity Strategy 2030 and the Farm to Fork Strategy.

Healthy ocean ecosystems are essential for climate change mitigation and adaptation. Rising ocean temperatures as well as ocean acidification mean that the capacity of the ocean carbon sink will gradually become weaker, changing ocean oxygen, nutriments and primary and export production, driving in changes in upper trophic levels. That is why the impact of climate change on ocean systems also affects sustainable fisheries, both globally and in the North Western Waters. Over the past 40 years, the Celtic Seas ecoregion has experienced significant changes with further increases in sea temperature expected over the coming decades. This can lead to changes in stock distribution, size and biomass which will need to be addressed and reflected in fisheries management.

To address these issues, the North Western Waters Advisory Council (NWWAC) established its Focus Group Climate & Environment in June 2020 to identify and examine the AC's needs in developing related advice. The Focus Group organised an online workshop in November 2020 to explore the challenges related to climate change to fisheries in the NWW and to examine potential mitigation and adaptation strategies, bringing together invited experts, stakeholders from the ACs and representatives from the European Commission. A detailed report was produced and published in the NWWAC's three working languages (link).

The outcomes of this workshop fed the preparation of this advice to the European Commission, aiming at providing an overview of potential mitigation and adaptation strategies, as well as identifying tools and mechanisms in support of the fleets in the NWW.

2. Climate change challenges and opportunities for fisheries in the NWW

An increase in sea water temperature has been recorded in the large Atlantic Ocean, linked to water circulation and sea surface stratification. Climate impacts on coastal ecosystems' biodiversity, structure and functioning and the levels of risk under future conditions of global warming are mixed and complex, depending on each coastal ecosystem's adaptations. South West UK seas (Celtic Sea, Channel and Southern North Sea) are rapidly warming, with projections seeing temperature increases of 2 to 4 degrees by the end of the 21st century, with higher temperature increases especially closer to the coast, in the areas that are critical for fisheries.

With these waters getting warmer, the boundary between cooler northern waters and warmer southern waters in this area is getting more blurred, and ecological impacts on fish species (e.g., spawning times, altered community compositions) have already been experienced.

A study[1] by Alan Baudron in the North Sea in 2014 using the DATRAS database for eight commercial species in the North Sea as well as some long-term data from the Netherlands market sampling programme for flatfish examined the impact of temperature increase on individual growth rates. Results show a common trend, with the maximum adult body size decreasing as the temperature of the North Sea increased. As a consequence, the yield per recruit showed an average decline of 23%.

Spawning times are also temperature dependent. This was detected for cod in both the North Sea and in the Irish Sea, as reported in a study[2] published in 2017, which identified a shift to earlier spawning times. Earlier spawning has the potential to create a mismatch with larval prey, and as the mismatch index increases, the recruitment rates will decrease through food limitation, thus impacting survival. The features of this correlation were consistent in the two areas analysed in the study. Thus, temperature dependency of growth rates and spawning times have the potential for decreasing productivity as waters warm.

15 stocks in the Celtic Sea can be expected to reduce in the expected MSY, which will have an impact on the management of these species. Haddock is currently below its temperature preference. Cod and herring are outside their temperature range in the Celtic Sea. There are also species that will probably do better with increasing temperature, such as hake, sole and *Nephrops*.

Looking at cod recruitment in the Celtic Sea, there is high variability over the years. Peaks in cod recruitment occurred in years when the water temperature dropped below 10 degrees. Cold water in the Celtic Sea and Irish Sea is driven by the North Atlantic Multidecadal Oscillation, which is currently in a down phase, but can be expected to start warming in the coming years with Climate Change. This means that 2014 might have been the last good recruitment year for cod.

Contrasting potential future declines in anglerfish, Atlantic cod or megrim, the mentioned abundance expansions may provide new or further fishing opportunities (e.g. red mullet, John Dory, Dover sole) but that depends on fisheries access, markets and adaptability. It also depends on policy responses that aim to ensure resilience and sustainability of both marine ecosystems and coastal communities.

Overall, climate change has several effects on fish, fish stocks and fisheries:

- Shifts in abundance and distribution of fish stocks as the ocean warms: both northern and southern fish stocks are projected to have higher rate by species' expansion from lower latitude as species find it easier to grow at higher latitude.
- Changes in phenology (timing of spawning and maturing) and body size occur as the water gets warmer: fish tend to mature earlier and at smaller sizes in warm water, which will also alter their distributions.
- Fish use more energy to live in warm water, with less energy allocated to growth and reproduction; acidification may also increase energy use.
- Storminess and extreme weather events, which have fundamental roles in shaping fishers' behaviour, increasing levels of physical risk, discomfort and trip profitability, besides increasing risks for coastal ecosystems.

[1] Baudron, A. R., Needle, C. L., Rijnsdorp, A. D., & Tara Marshall, C. (2014). Warming temperatures and smaller body sizes: synchronous changes in growth of North Sea fishes. Global change biology, 20(4), 1023-1031.
[2] McQueen, K., & Marshall, C. T. (2017). Shifts in spawning phenology of cod linked to rising sea temperatures. ICES Journal of Marine Science, 74(6), 1561-1573.

3. Recommendations on adaptation measures

Recommendation 1: Ensure flexible and adaptive fisheries management

In a report already published in 2016, ICES has highlighted how the effects of global warming are altering the traditional fisheries management areas, which inevitably means changes in the way the fishing sector can exert its fishing rights. The displacement of fish biomass as a consequence of climate change requires an adjustment of management areas and quota allocation. Having an efficient system to allocate fishing rights, adaptive to the movement of fish stocks, is a precondition for good management.

Given the temperature-dependency of fish's vital rates, current reference points in stock assessment, i.e., BMSY and FMSY, which are based on historical levels of productivity, will need to be adjusted for expected future levels of productivity.

In order to accommodate the awareness of climate impacts on fisheries resources management, appropriate policy responses are needed that focus on supporting planned adaptation solutions:

- Carry out vulnerability assessments of stock decline through fishing, taking into account the overall context of natural stock decline in response to global warning, i.e. migration to higher latitudes, on a species-by-species basis. The species identified as most vulnerable should be prioritised in adaptation planning.

- Develop responsive harvest control rules for the most vulnerable species, without compromising catches of species found in abundance and sustainably managed in mixed fisheries. The NWWAC advises that any technical measure or quota limitation is carefully designed to avoid choke issues and premature fisheries closures.

Recommendation 2: Develop a communication campaign to better involve realities on the ground in the policy innovation process and incentivise stakeholders' support and engagement in adaptation initiatives

When thinking about managing and adapting to climate change, it is important to understand people's willingness and support for initiatives, their behavioural intentions and the constraints and barriers they see to adaptation. There sometimes are worrying gaps between climate policy responses and local realities which have already led to social tensions in the past within the EU borders. Engagement with coastal communities is vital to ensure equity in climate-related policies.

Awareness of impacts may not necessarily translate into perceived need or willingness to prepare for and adapt to future impacts: fishers identify numerous non-climate risks for the future, while climate change is often regarded as low risk. These low-risk perceptions are influenced by scepticism and perceived ability to adapt. Low risk perceptions and scepticism suggest potential issues regarding the perceived legitimacy of future climate-orientated fisheries management measures.

Fishers' future responses depend on both their perceptions of change and their capacity to change. Incentivising adaptation through awareness raising will likely be insufficient; fisheries adaptation planning should also tackle wider constraints and future non-climate risks (environmental, socio-economic and governance risks). Recognising these risks and considering how they may influence

fishers' responses to climate change is crucial given that some of these risks will affect the wider adaptive capacity and resilience of fishers to climate impacts[3].

Further work is needed to understand perceptions of multiple stakeholders and their willingness to support adaptation initiatives before these can be implemented. This could be achieved through inclusive decision-making processes or the adoption of co-management approaches, which have the potential to facilitate conflict resolution, as well as improving transparency and trust in both how decisions are made and the information used to inform these decisions.

Recommendation 3: Examine emerging species markets and catch potential

Shifts in species' distribution could mean an increase in warm water species biomass in the NWW, which in turn would provide new catch potential. The rise in emerging species biomass could allow fishers to access new markets. While this could be an opportunity for fishers to survive to climate impacts in the ocean, it remains a major challenge from an economic point of view, as it entails not only accessing new markets but also creating new markets and a consumer demand for new fish species. Should this be seen as a viable option to allow the fishing sector to adapt, it would require policy measures aimed at introducing citizens and consumers to new fishery products and the creation of a culture of buying what is available rather than focusing on traditional species. Innovative public-private partnerships between institutions, industry and NGOs can be of advantage in educating consumers on these issues.

Recommendation 4: Improve monitoring and infrastructure to reduce the risk of adverse working conditions

Projections of future storminess are very uncertain, but generally more frequent, larger storms are expected, which challenges the security and safety of maritime activities. In light of this, storminess should be increasingly incorporated in fisheries climate vulnerability assessments. It is also fundamental to improve safety on board to mitigate the risk associated with storms. This would require a more adaptative management of the fishing effort, which should not be solely based on fishing vessel design (i.e. on gross tonnage or engine power), as more equipment or higher power engines might be needed to face increasing storminess and improve safety on board, without increasing the fishing pressure. Port infrastructures and the whole value-chain should also be taken into account in increasing the adaptation and resilience of fishing activities.

4. Recommendations on mitigation measures

There is clear evidence for observed climate change impacts throughout the ocean with consequences for human activities, and solutions are required to reduce risks and impacts. At his level, the main carbon emission from fishing is represented by the fossil fuel consumption to catch fish. However, some studies[4] indicate that some types of fisheries also can have a direct impact on carbon reservoirs on the seabed and on the ability of the marine ecosystem to store carbon.

[3] Maltby, K. M., Simpson, S. D., & Turner, R. A. (2021). Scepticism and perceived self-efficacy influence fishers' low risk perceptions of climate change. *Climate Risk Management*, *31*, 100267.

[4] Luisetti, T., Turner, R. K., Andrews, J. E., Jickells, T. D., Kröger, S., Diesing, M., ... & Weston, K. (2019). Quantifying and valuing carbon flows and stores in coastal and shelf ecosystems in the UK. Ecosystem services, 35, 67-76.

Recommendation 5: Decarbonise the fishing sector

According to the objectives of the Green Deal, the European economy needs to be climate neutral by 2050. The contribution of the total maritime sector to total CO_2 emissions is less than 3%, with the fisheries sector's footprint being very small. However, the sector needs to be part of the solution and not the problem, embracing the cost of decarbonization from day one.

Technology that would support the decarbonization of the sector is developing and improving. Options include improvements in engine functioning and the use of different energy sources (solar, wind and hydrogen). LNG and hydrogen fuel-cell technologies seem to be the most promising alternatives. Quite a lot of activity is taking place worldwide in this regard[5]. Such projects are good examples for the European sector to consider for future perspectives. Hydrogen technology could be a steppingstone towards a carbon free seafood industry. Electric power might be feasible for certain fleet segments, for example coastal, small scale fleets.

It is important that the fisheries sector receives enough attention in the 2021-2027 funding programme to ensure that its needs are examined in the developments of these new technologies. The European Commission has been investing in research in hydrogen technology and has funded 108 projects related to this under the Horizon 2020 programme. However, only a few were related to the maritime sector and even fewer to the fishing sector.

In the case of a shift towards alternative fuels, several logistic issues need to be considered in relation to marketing, ports equipment (charging stations, LNG storage, etc.), maintenance and crew training. EU fishing companies are continually devising and implementing creative solutions to save energy. However, the current technologies are still not a direct alternative to fossil fuels, and while the industry is trying to reduce its environmental impact by improving engine and gear efficiency, more knowledge is needed regarding technological possibilities.

The 1992 reform of the Common Fisheries Policy imposes limitations on the tonnage and propulsive power of EU vessels. While this has not changed in the past 25 years, it is a shared opinion among fishing professionals that vessel tonnage is poorly suited to the economic and technical challenges that arise for the construction of today's vessels (including purposes of seeking better profitability, better crew comfort and installation of technologies that minimise the sector's environmental footprint). The origin of the need for additional tonnage faced by fishing companies is probably due to the fact that the current framework does not anticipate the implementation of new technologies (LNG, hydrogen, etc.) and does not consider the search for better energy efficiency beyond the current mandatory standard.

Overall, there are both regulatory and technological constraints to the energy transition of EU fishing vessels. The future evaluation of the CFP can play a very important role in the development and evolution of this framework and thus in the energy transition of the EU fishing sector.

Another key aspect is to understand the fuel efficiency and the food production efficiency of our fisheries. For wild capture fisheries, the actual food production efficiency, in terms of tonnes of landings per unit of fuel consumed to catch that food, compares very favourably to other forms of food production. However, this is not a uniform picture and depends on the type of fishery. Having more detailed information about the efficiency across the different metiers in the fleet would really help governments to target financial incentives and investments to improve particularly problematic sectors of the fleet to help them meet the zero-carbon agenda. This would also be important as part of a larger conversation on climate neutrality in relation to food systems. Having a science-based understanding of the contribution of seafood to climate-neutral diets and informing consumers

[5] There is a particularly interesting case in Japan, where national research institution in cooperation with the Toyota corporation is developing a 19 tonnes fishing vessel running on hydrogen produced entirely by an offshore wind park.

accordingly would help the EU to transition towards a climate-neutral economy while avoiding nutritional deficits among EU citizens.

Recommendation 6: Protect marine ecosystems

Benefits of avoiding habitat disturbance and destruction are not limited to biodiversity protection, but also relate to climate by decreasing carbon emissions while increasing its sequestration.

One of the most important initiatives for the conservation, sustainable use and benefit-sharing of biodiversity worldwide is the Convention on Biological Diversity (CBD)[6]. The CBD's objectives are reflected in the EU Biodiversity Strategy for 2030, which is committing to legally protect a minimum of 30% of the EU's ocean area through Marine Protected Areas (MPAs) and Other Effective Conservation Measures (OECMs) and integrate ecological corridors. It is essential that fisheries stakeholders are involved in the design and implementation of these protected areas.

There is also an ongoing need to improve vessel design and gear design in relation to reducing direct effects on the seafloor. Alleviating the physical contact between the gear and the seabed is certainly going to reduce fuel consumption. This is another area where the 2021-2027 funding programme can play a crucial role in the continual development of an EU fishing industry that is truly empowered to keep contributing to climate mitigation efforts.

One of the other advantages of reducing physical contact with the seabed is the reduction in the secondary negative impact on the biological system. Theoretically, as we reduce gear's contact with the seafloor, this decreases the amount of marine organisms disturbed in the sediment. A strong focus is currently placed on those habitats with the highest potential to mitigate climate change, by capturing and storing carbon. The NWWAC appreciates that some research is ongoing in the context of the EU Biodiversity Strategy to explore the role of many marine habitats in carbon capture and storage. It is important to mention in this regard that the reliable determination of sediment accumulation rates is a key consideration to make, with associated uncertainties not fully reflected. As also recalled in the last IPCC Special Report on the Ocean and Cryosphere in a Changing Climate[7], there is a lack of data and understanding of the complex processes that affect carbon storage in the potentially mobile fraction of marine sediments[8]. Due to these uncertainties, there is currently insufficient confidence that control of sediment disturbance can be used for climate mitigation. EU-funded research should foster understanding on this topic, so that future decisions are informed by a strong scientific basis.

Recommendation 7: Continue the commitment towards the MSY objective

According to recent research[9], when overfishing is combined with climate change, which has several impacts on its own (increased temperature, salinity, hypoxia and acidification), it is clear that fisheries are under an intense pressure.

Some of the key actions in this regard include setting fishing limits in accordance with the MSY target or the precautionary approach and managing the climate and ecosystem impacts of fishing to protect food webs, habitats and ecosystem functioning. In the EU stocks assessment (including the ICES

[6] The CBD Aichi Target 6 (sustainable fisheries) and 11 (10% of marine and coastal areas under EEZ to be covered with conservation measures) were to be achieved by 2020.The CBD COP 15 will then adopt the Post-2020 Global Biodiversity Targets, which will replace the Aichi Targets.
[7] https://www.ipcc.ch/srocc/
[8] van de Velde, S., Van Lancker, V., Hidalgo-Martinez, S., Berelson, W. M., & Meysman, F. J. (2018). Anthropogenic disturbance keeps the coastal seafloor biogeochemistry in a transient state. Scientific reports, 8(1), 1-10.
[9] Mariani, Gaël, et al. "Let more big fish sink: Fisheries prevent blue carbon sequestration—half in unprofitable areas." Science advances 6.44 (2020): eabb4848.

assessments) and management system, the cumulative impacts of fisheries are evaluated through the stock assessment itself and the setting of TACs "at MSY". However, this is not the case for other activities that have impacts on stocks or their habitats (for example potential losses of a fisheries functional area in a coastal ecosystem due to other marine-based activities), which need to be explored and considered through an ecosystem-based approach to fisheries management.

Finally, NWWAC members advise that more attention is given to the understanding of the role of fish in blue carbon[10], in terms of how fish influence carbon absorption and sequestration in the ocean by contributing to the biological pump of marine life that moves carbon through the ocean cycle[11] [12].

5. Conclusions

Fisheries are at the centre of climate adaptation and mitigation and this needs to be reflected in all policies and practices concerned. Fishers are highly interested in taking care of the seas and oceans, and ensuring the survival of marine species, since their way of life and livelihood depend on it. The EU fishing sector is a global leader in sustainable, science-based fisheries management based on the most ambitious internationally agreed management objectives. The sector is also continually investing in better waste management plans, reduced energy consumption and smarter procurement of sustainable materials and supplies to decarbonise the industry.

The biggest challenge facing the industry is the development and global availability of alternative and innovative green technologies and carbon-neutral fuels and energy sources. Proposals to intensify efforts on the production and deployment of such fuels and the necessary infrastructure is very much welcomed by the industry. However, the transition to new propulsion technologies requires larger space on board and current capacity limitations of fishing vessels set in the CFP hinder such progress.

The fishing sector is aware of climate change impacts and much interested in any solutions that could mitigate these. Nevertheless, one of the main challenges relates to the (lack of) knowledge supporting measures to be implemented in this regard. Having a sound scientific basis is crucial to achieve balanced objectives across all three pillars of sustainability, allowing for both the better protection of threatened ecosystems and a thriving and competitive European fishing sector. At the same time, involving stakeholders in the decision-making process is vital to ensure that these measures and strategies are just, inclusive and effective.

To conclude, NWWAC members would like to recall that a sustainable European fishing industry produces a low carbon, high-value protein for consumers, compared to other animal protein producing sectors, and highlight the importance of promoting seafood as part of sustainable, climate-neutral food consumption.

[10] In the open ocean, the biological carbon pump is driven by the combination of photosynthesis by phytoplankton and downward transfer of particulate carbon by a variety of processes. The term “blue carbon” was originally used to cover biological carbon in all marine ecosystem. Subsequent use of the term has focused on carbon-accumulating coastal habitats structured by rooted plants, such as mangroves, tidal salt marshes and seagrass meadows.

[11] Henson, S. A., Sarmiento, J. L., Dunne, J. P., Bopp, L., Lima, I., Doney, S. C., ... & Beaulieu, C. (2010). Detection of anthropogenic climate change in satellite records of ocean chlorophyll and productivity. Biogeosciences, 7(2), 621-640.

[12] DeVries, T., Holzer, M., & Primeau, F. (2017). Recent increase in oceanic carbon uptake driven by weaker upper-ocean overturning. Nature, 542(7640), 215-218.