# The Triple Challenge in UK Offshore Wind Farms

## A Multistakeholder Approach Through Key Informant Interviews

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## *Abstract*

As more countries shift from fossil fuels to green energy, it is critical to understand how this shift can be made sustainable and how to ensure all aspects of the "triple challenge" of climate, nature, and human wellbeing are addressed. In this study I examined offshore wind energy in the UK from the perspective of its impacts on the climate, the local marine environment, and communities in related coastal areas. I conducted a scoping review of UK marine policies to assess the UK's priorities in their national waters and found that offshore wind energy is prioritised over other marine goals. I also conducted key informant interviews with ecologists, government officials, fishing community representatives, and wind farm developers, to capture their experiences and perspectives on the policies. I found that the majority of participants felt positively about decarbonisation but that both the fishing community representatives and ecologists had other concerns. Fishers were primarily concerned about losing fishing space, and ecologists about the unknown impacts on biodiversity. Across the four sectors, there was widespread agreement regarding the need for more coordinated and comprehensive offshore wind farm (OWF) policy that includes a better marine spatial plan and more cohesive onshore infrastructure.

## *Introduction*

The dual global crises of climate change and nature depletion are widely recognised internationally. Governments working to address these two crises have the additional challenge of doing so while maintaining human well-being. This problem is sometimes referred to as the "triple challenge" (Baldwin-Cantello et al., 2023). These three goals are addressed independently in policies and legislation even though they are interrelated issues. The expansion of off-shore wind farms (OWFs) embodies this challenge as it addresses the climate crisis, but can have impacts on local ecology and communities. Given the current rapid expansion of wind farms in the UK, it is an important and timely topic to study (figure 1). In this study I have examined the UK's wind energy policy and the expansion of UK wind farms from the perspective of the triple challenge, focusing primarily on the marine environment and the well-being of fishing communities.


*Figure 1. Map of current and proposed wind farms in the UK. Shown here to demonstrate the extent of wind farm expansion in British waters. Grey sites are proposed development zones, future wind farms planned within them will likely not take up the whole space as not all areas are suitable for wind farms to be built (4C Offshore, 2023)*

## *Background: Defining the triple challenge in OWFs*

To understand perceptions of wind farms, it is important to define the triple challenge as it pertains to them. The main aspects investigated in this study are the diverse impacts of OWFs on the environment and on local communities.

### Environmental Impacts

The life cycle of an OWF is thought of in 3 stages: construction, operation, and decommissioning. During construction, the environmental impacts are negative. First, driving the pylons into the sea floor can cause underwater noise. The noise can displace marine mammals temporarily as they avoid it (Bailey et al., 2010). Second, there can be physical damage to fish that cannot move from the site (Bergström et al., 2014; Debusschere et al., 2014). Third, sediment dispersal caused by driving pylons into the seafloor can cause damage to immobile species in the area and can lead to higher turbidity that some species cannot tolerate. The issue of sediment dispersal does not appear to have long-term impacts as seafloors settle once construction is done (Bergström et al., 2014; Dannheim et al., 2020). Cable-laying, however, is thought to have significant negative impacts as it covers up areas of the seafloor, removing valuable habitat (Degraer et al., 2020; RSPB, 2022).

During operation, evidence points to both positive and negative impacts (figure 2). Negative impacts include electromagnetic (EM) interference, noise disruption, current interference, and ecological community structure changes due to the presence of new structures on the seafloor (Galparsoro, 2022). EM interference is due to the electricity generated by the turbines and passed through the cables on the seafloor. This only has an impact on species that communicate or navigate via electromagnetism, like elasmobranchs (Hutchison et al., 2020). Some studies suggest that the vibrations and noise from the pylons lead to avoidance by marine mammals, but this is not well understood and does not seem to cause actual damage to their populations (Bergström et al., 2014; Galparsoro, 2022). Studies also suggest OWFs can cause water current disruption or a change in water stratification (Carpenter et al., 2016). Though there is little observational research on this impact, models suggest that the current passing through wind farms would be disrupted enough to impact the spawning of some species (Barbut et al., 2019; Gill et al., 2020).

There is also research showing an increase in biomass around the wind farms through the artificial reef effect. The artificial reef effect is a well-studied phenomenon on oil rigs and other marine infrastructure (Claisse et al., 2014). It occurs because communities of sessile species like mussels, barnacles, and anemones can grow on underwater structures. These communities then ingest particulates in the seawater and defecate onto the seafloor (Degraer et al., 2020). Fish accumulate around them, and it can lead to a local increase in biomass. These communities become known as artificial reefs (Bergström et al., 2014). This is not, however, always associated with an increase in biodiversity because these communities can be dominated by one species, like blue mussels (Bergström et al., 2014). The artificial reef effect is sometimes considered a positive ecological impact of wind farms and other underwater structures, but there is limited research and knowledge of the long term effects of these ecological changes. It is also unknown whether they increase biomass overall or just concentrate it in one area.

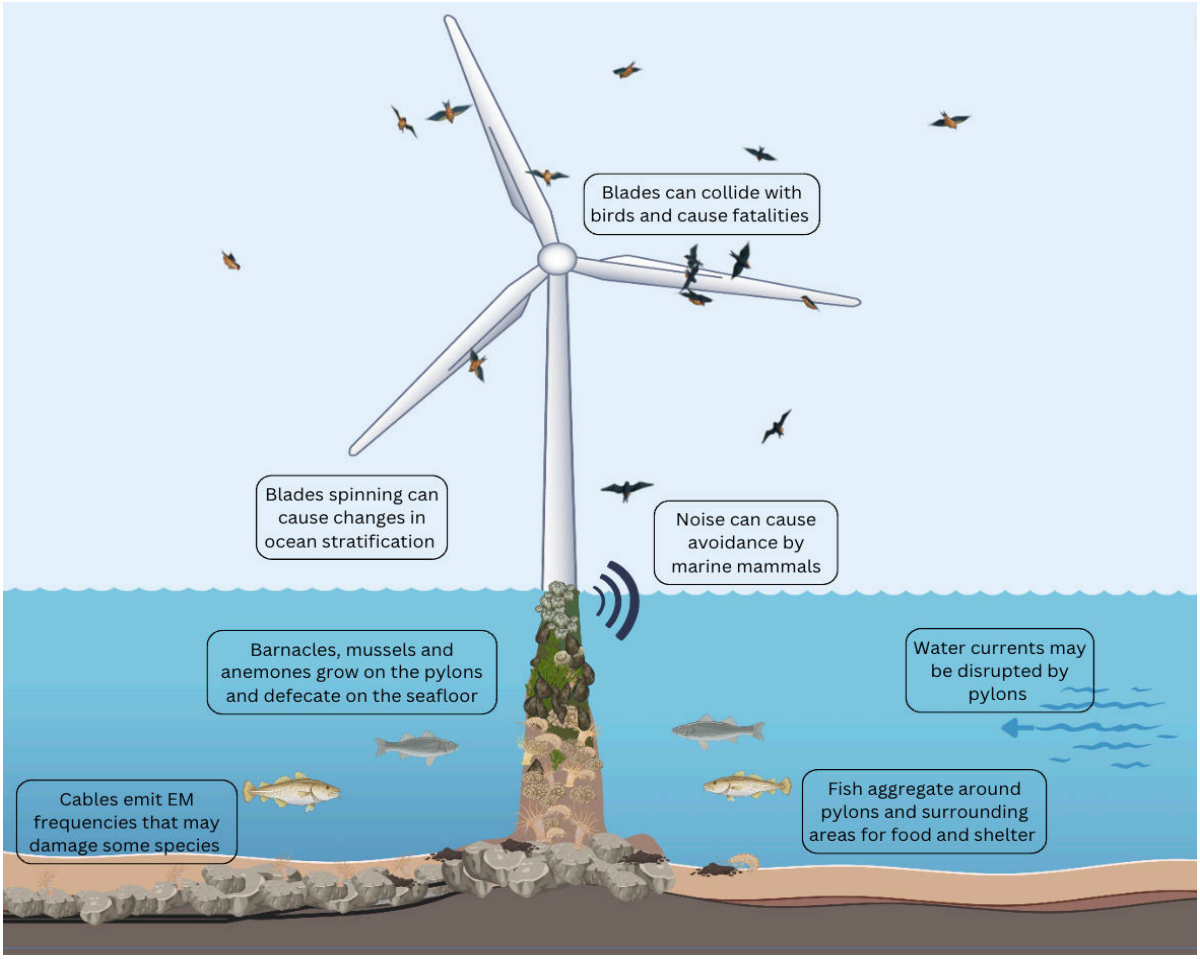



*Figure 2. Summary of effects of each individual turbine constructed. Not to scale.*

Some studies suggest that OWFs may have positive ecological effects by acting as de-facto marine protected areas (MPAs) (Bergström et al., 2014). This is particularly true in cases where fishing is banned or actively discouraged. Thus far, however, there is little evidence of this being the case in the UK (Dunkley & Solandt, 2022; Galparsoro, 2022).

The impacts of the decommissioning of OWFs are unknown at scale. So far there has only been one decommissioned OWF in the UK consisting of two pylons (Crown Estate, 2019) , which is not comparable to current OWFs with hundreds. This is because most OWFs in the UK are less than 30 years old (the typical life span of current OWFs). Current UK policy states that wind farm pylons and foundations must be dug up and completely removed at the end of their lifecycle (Topham & McMillan, 2017). This would destroy any communities created through the artificial reef effect (Fowler et al., 2015) and could cause further disruption to the seafloor.

## Socio-economic impacts

In addition to environmental impacts, there has been research on the socio-economic impacts of OWFs. They have often been proposed as a solution to the political backlash that onshore wind farms have faced from so-called NIMBY (not-in-my-back-yard) movements (Devine-wright 2011). This led to research on the social acceptance of wind farms by small communities and stakeholders. Multiple studies have concluded that social acceptance depends on the location of the OWF and the perceived economic effect they will have on local communities (Devine-wright et al 2017, Kermagoret et al 2016). One study found that locals who used the coastline were less likely to view the OWF favourably (Kermagoret et al 2016). This fits with previous research suggesting that acceptance of industrial development is dependent on a number of social factors including “place” or people’s attachment to their environment (Devine-wright et al 2009). The sense of attachment to one’s environment is especially important in industries like fishing where they rely on their surroundings for their livelihoods (Haggett et al., 2020).

In addition to social harms that can come from losing marine areas, there can be economic harms associated with losing fishing grounds. This has been studied in Taiwan where a comprehensive marine spatial plan was studied to protect historical fishing communities (Zhang et al 2016). In the UK, however, there has been little research on the direct economic impacts of wind farms on local communities. This may be because wind farms at the current

scale are still too recent for their long-term economic impacts to be studied. The studies that exist have examined ways to mitigate economic harms by integrating wind farms with fisheries because, even in situations where fishing is not banned around OWFs, it has been shown to decrease (DeBacker, 2017). There is currently no standard practice for OWFs to ensure fishing can occur safely within them (Schupp et al., 2021).

The National Federation of Fishermen's Organisations (NFFO) and the Scottish Fishermen's Federation (SFF) issued a joint statement in June of 2022 outlining the risks that the expansion of OWFs and MPAs pose to the fishing industry. The report clearly states their belief that the needs of the fishing industry will be pushed aside to accommodate other governmental goals. This could have negative impacts on coastal communities, food prices, and other industries associated with fishing. It could also lead to ecological impacts in areas where fishing becomes more concentrated as more fishers are displaced into those remaining areas. In turn this could result in conflicts between the existing and newly displaced fishers (NFFO, 2022).

## The Triple Challenge

It is clear how the expansion of OWFs impacts all areas of the triple challenge. While necessary for the decarbonisation of the UK, OWFs may impact marine life in our seas and the well-being of coastal communities (figure 3).

OWF policy plays a key role in determining which of these consequences will be felt the most, and where. In this study I aim to understand the perceptions that different groups have of OWFs, as well as the policy context for those perceptions.

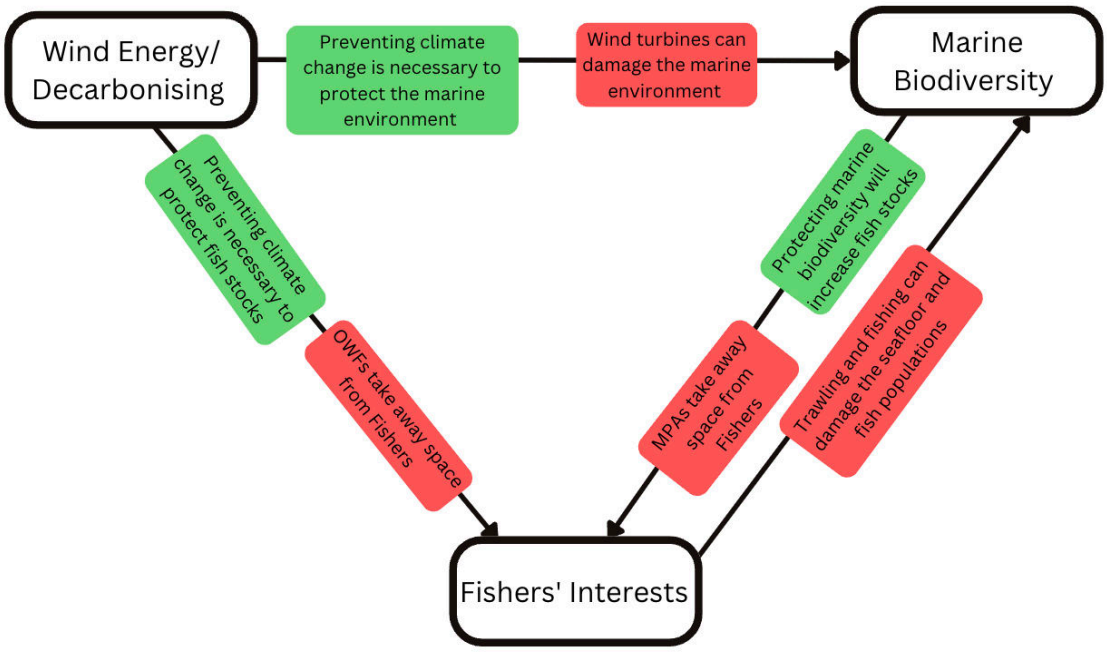



*Figure 3.*
*A simplified display of the triple challenge in the context of wind farms in the UK and their impacts on fishing and the marine environment, as informed by current literature. The red bubbles show negative interactions and green ones show positive interactions. The areas of the triple challenge all interact with each other but this diagram aims to show that wind energy impacts both fisheries and marine biodiversity, while marine biodiversity goals and fisheries currently have no discernible impacts on wind energy.*

The key research questions were as follows:

- What are the relevant, different policy contexts for the expansion of OWFs?
- What are the perceptions of the costs and benefits of OWFs among different stakeholder groups?
- What are the concerns or perspectives of different stakeholders regarding the UK's current OWF policy?
- How does this inform our understanding of the triple challenge, including trade-offs and synergies in the expansion of offshore wind in the UK?

My hypothesis was that decarbonisation would be seen by all as a key priority, and would feature heavily in UK policy. I predicted that all groups except fishers would value the benefits of decarbonisation against related local costs, but that fishing communities would not see decarbonisation as a benefit compared to the economic costs they face. I also predicted that fishers and ecologists would feel excluded from the policy around wind farm location allocation.

# *Methods*

## Overview

I began by conducting a review of current policies to provide context for the key informant interviews. In the key informant interviews I spoke to fishers, ecologists, wind farm developers, and civil servants about their perspectives on the costs and benefits of wind farms in the UK. I also focused on their views on wind farm policies and current practices in the UK. This informed the analysis of the key trade-offs and synergies related to the expansion of wind farms.

## Policy review

I began by identifying the three areas of policy I wanted to investigate. I looked at wind farm policy, marine nature recovery policies, and fisheries policies because of their interactions as part of the triple challenge. I then identified relevant policies by searching the UK government websites for key relevant phrases. I searched the Gov.UK website, and the legislation.co.uk website. The reason for using both was to ensure maximum reach. The Gov.UK website especially was useful because it included press releases with key words that made it possible to identify important policies buried within legislation that other searches did not identify. I selected relevant legislation and policies based on the following criteria:

- Were they restricted to UK seas?
- Were they passed within the last two decades?
- Were they the most recent piece of legislation or policy statement in that area? (i.e. eliminating previous equivalent policies)
- Were they a large-scale policy (i.e. eliminating polices aimed at specific fisheries or one type of marine environment)

I consulted my co-supervisor from the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) for assistance in identifying and interpreting relevant policies.

## Interviews

*Choice to conduct interviews:*

This topic is complex, current, and changing in real time. This makes it difficult to collect data using a quantitative survey, or even closed form questions. Following my desk research, I

developed a questionnaire for the survey along with the interview requests, however this survey was excluded due to the fact that it did not include the majority of views brought up by the participants. Survey results and procedure are included in Appendix 1. A main goal of this study was to identify areas of concern that differed between parties, and therefore allowing a free form response was more appropriate.

*Identifying interviewees:*

I first selected the stakeholder groups. Given the limitations of time and scope of the study, I focused on representatives of the fishing community and ecologists given that both groups are effected by the expansion of wind farms, and have been outspoken on the topic (NFFO, 2022; RSPB, 2022). My second cluster included wind farm developers from private sector companies and UK government officials involved with wind farm expansion and related policy development. I began my search for individuals to interview by contacting companies, fishers' federations, environmental NGOs, and government agencies that were relevant based on my previous research. I continued my search by looking at affiliated organisations of these places. I also used public records of wind farm leasing rounds to identify groups and individuals. I then expanded my search to LinkedIn and Google to identify specific individuals responsible for the relevant areas of work. On LinkedIn and Google I searched for the phrases "Wind energy North Sea", "MPA UK", "Marine ecologist UK", "wind energy advisor", "North Sea fish", "UK fish" "Energy advisor UK". I contacted 61 individuals and organisations, 17 of whom responded, and 14 of whom agreed to be interviewed. Some individuals did not identify directly with one of the groups, including one former civil servant turned marine policy consultant, and one researcher involved with marine protected areas. I grouped these with the civil servants and ecologists respectively because their expertise pertained more closely to those groups.

*Conducting interviews:*

The interviews were semi-structured and conducted over Microsoft Teams. I took written notes and audio recordings that I later transcribed, except in cases where individuals requested not to be recorded. I followed CUREC best practice for conducting elite interviews, and recommendations laid out in Solarino and Aguinis (2021) for key informant interviews. I asked questions that covered their experience with OWFs, their view on their benefits, their view on

their costs, and their views on wind farm policy in the UK. A detailed interview protocol is in Appendix 2. Interview results and quotes were anonymised.

*Interview analysis:*

I followed thematic analysis guidelines laid out in Braun and Clarke (2012). I began by identifying key topics that arose multiple times. I then sorted these into themes and looked at patterns across and within the groups. I sorted the themes and topics into costs and benefits once I had identified them all. I did the same with policies that were mentioned. This method enable me to identify the frequency with which each topic was mentioned by different groups, and the patterns that set certain groups apart from others. Some interviewees mentioned policy opinions in tandem with costs or benefits. I attempted to correct this by asking them to expand on any policy opinions mentioned.

# *Results*

## Part 1: The Policy Context

As documented in Table 1, I identified 16 policy papers and bills pertaining to fisheries, offshore wind energy, or marine biodiversity that give context for the wind farm expansion in the UK. I found no specific targets for the fishing industry in terms of their economic output or food production, even though their importance is acknowledged in policies like the Brexit agreement and the Fisheries Act. I found a few specific marine biodiversity targets including for protecting large areas of the UK seas. The targets deadlines are for 2042 which is significantly later than the energy targets deadlines of 2030. I found three different wind energy targets in different policy papers and statements that all set different targets for offshore wind farm capacity by 2030. These targets fall between 30GW and 50GW by 2030, a significant difference that points towards an ambitious but disorganised push to decarbonise the UK. I also identified policies that attempted to address multiple issues at once, including policy on environmental assessments for offshore energy structures. There were no policies directly pertaining to fishing in offshore wind farms.

| | Policy | Description | Specific Target | Deadline | Citation |
|---|---|---|---|---|---|
| Environmental policy | UK Marine Strategy Parts 1-3 (Updates for 1&2 have been published in 2019 and 2022) | Strategy to make sure the UK achieves good environmental status (GES) in the seas. Defines GES for different types of Marine Protected Areas (MPAs) | None | None | (*UKMS Part Three*, 2015 ; *Updated UKMS Part One* 2019; *Updated UKMS Part Two* 2022) |
| | 2021 Environment Act | Covers environmental targets including marine targets. | 70% of MPAs in "favourable" condition and 30% "recovering" position | 2042 | ("Environment Act 2021," 2021) |
| | Environmental Targets for MPAs 2022 | Additions to the Environment bill making the above targets binding | Same as above | 2042 | ("The Environmental Targets (Marine Protected Areas) Regulations 2022," 2022) |
| | 25 Year Environment Plan (25YEP) | Series of targets to be achieved with 25 years of 2018<br>Includes non-specific target of "reversing the loss of marine biodiversity and , where practicable, restoring it" | None | 2043 | (*25 Year Environment Plan* 2018 ) |
| | Environmental Improvement plan 2023 | First revision of the 25YEP- Summary of what the UK has achieved. Includes having set a target of 30% MPA coverage | 30% MPA Coverage | 2043 | (*Environmental Improvement plan* 2023) |
| Fisheries relevant Policy | The Trade and Cooperation Agreement 2021 | Trade agreement between the UK and EU upon the UK's exit from the EU<br>Highlights the importance and difficulty of splitting fisheries | None | None | ("The Trade and Cooperation Agreement (TCA)," 2021) |
| | UK Food Strategy 2022 | Strategy to feed population while recognising the nature crisis. Highlights fisheries | None | None | ("Government food strategy," 2022) |
| | UK Fisheries Act 2020 | Manages commercial fisheries in UK waters – focuses on sustainability of fisheries | None | None | ("Fisheries Act 2020," 2020) |
| | UK Joint Fisheries Statement 2022 | Sets out plan to deliver the Fisheries Act. Explicitly recognised the socio-economic importance of maintaining sustainable fisheries | None | None | (*Joint Fisheries Statement*, 2022) |
| | Fisheries and Seafood Scheme 2022 | Money available to make fishing more sustainable, increase demand for English seafood, or work in sustainable aquaculture | None | None | (*Fisheries and Seafood Scheme*, 2021) |
| Wind Energy Policy | Climate Change Committee (CCC) recommendations + Net Zero Strategy 2021 | Pledge by the UK to meet the net zero targets laid out by the CCC | Net Zero Carbon | 2050 | (*Net Zero Review* 2021) |
| | The Ten-Point plan for a Greener Industrial Revolution 2020 | Strategy document for decarbonising the UK's industrial sector | 40GW offshore wind energy | 2030 | (*The Ten Point Plan for a Green Industrial Revolution*, 2020) |
| | Offshore Wind Sector Deal 2020 | Agreement between government and offshore wind industry to make the UK a leader in offshore wind | 30GW offshore wind energy | 2030 | (*Offshore Wind Sector Deal* 2020) |
| | British Energy Security Strategy 2022 | Strategy for UK energy security and independence from oil and gas from other countries | 50GW offshore wind energy | 2030 | (*British energy security strategy*, 2022) |
| Combination policies | MMO Strategic Plan 2022 | Plan for sustainable ocean use through 2030. Included in this is a goal to create a marine plan | None | 2030 | (*MMO Strategic Plan 2030*, 2022) |
| | The Environmental Assessment of Plans and Programmes Regulations 2004 | Process aimed at making sure that new offshore energy developments are not too damaging to the environment. Includes the Strategic Environmental Assessment (SEA) process | None | none | (*The Environmental Assessment of Plans and Programmes Regulations*, 2004) |

*Table 1. Summary of relevant policies found*

## Part 2: Interview results

In total I interviewed fourteen people: four representatives of private companies involved in wind farm development, four fishers, three civil servants, and three ecologists.

*Perceptions of possible benefits*

All individuals interviewed acknowledged both the climate and nature crisis (n=14). They also acknowledged the role that wind energy could play in decarbonising the UK. The value placed on this benefit varied between groups. One ecologist said, "*any renewable is something you want to see.*" While another said, "*speed is crucial in tackling the crisis and wind is the fastest way we can get where we need to be*". The government and developers placed similarly strong emphases on the importance of green energy and its role in decarbonising society. Fishers also acknowledged this benefit and how it affects them. As one person stated "*Of course we want to stop climate change, the fishing industry is on the sharp end of it*". Though many of them caveated their support of decarbonisation with questions about the speed at which the UK is trying to cut emissions, one fisherman said, *"it's definitely the fastest, but is it the best?*"

The first real divergences came when they were asked about other benefits of OWFs. Fishers were quick to say that *"the companies get the first benefits"* (n=4). All of the developers (n=4) acknowledged this perception but said that developers benefit along with society. Two ecologists brought this up and one said that *"they are responding to a need; I don't think their presence is greedy"*.

Job creation was brought up as a benefit by most of the developers (n=3) and two of the civil servants interviewed. Both mentioned that both the supply chains for wind farm manufacturing, and the wind farms themselves would bring jobs. One civil servant said, *"if we can land the supply chain investment there is more than enough investment go to around to support the fishing industry"*. The value placed on the jobs created by wind farms was a major point of difference between the groups, and even between the civil servants interviewed. One of the civil servants said that the jobs created *"seem[ed] to be just written on the back of a fag packet"* and were not real jobs for which they could find any evidence.

Fishers did not believe that the wind energy industry would bring jobs (n=4). One fisherman brought up the fact that jobs rely on continued construction of wind farms, saying *"As soon as they stop building new [wind farms] what happens to those jobs?"* There was also

a widespread belief that jobs went to foreign specialists brought in by wind farm companies. One respondent noted, *"It's obviously cheaper not to train new people at each site, but can you really count those as jobs created?"*. Two developers acknowledged that jobs did not always go to locals. That said, they blamed it on the leasing agreements explaining that when the government values the cheapest bidder, the companies will always have to bring in cheaper foreign labour to make their bid competitive.

The potential local ecological benefits brought by wind farms through the artificial reef effect were dismissed by almost all of my interviewees (n=11). Most said that there may be some benefits, but the research was inconclusive and that decisions could not be made based on the assumption that OWFs will have a positive effect on local ecology. This was summarised by one ecologist who said, *"We wouldn't go and build wind farm pylons just so marine life can live on them … we want them for the energy- anything else is relatively incidental."* While one civil servant concurred saying, *"You wouldn't build Milton Keynes on pristine farmland and say its ok because some birds like Milton Keynes".*

The potential benefit of having OWFs as de-facto marine protected areas was brought up a few times (n=6), mostly by ecologists (n=3). The consensus was that OWFs could provide a potential benefit but that having them replace MPAs would be counterproductive. This was also raised by one fisherman as a potential cost for them. He expressed frustration at the idea that OWFs may be areas where fish aggregate, and that they could then be banned from fishing in them. *"It would be a two-fold hit if all the fish go there and we can't fish at all in them,"* he said.

Other benefits mentioned included economic benefits for the UK, as well as energy security. Cheaper energy was mentioned by one of the civil servants, as well as the developers (n=4), but others who brought it up (n=3) said that they had not yet seen a cost decrease. One of the fishers based in Scotland said their energy is largely powered by wind already, and they have not yet seen a decrease in prices. Energy security was another factor brought up by both civil servants (n=2) and developers (n=4). They mentioned that, especially with the current war in Ukraine, energy security is becoming important. One of the civil servants however, offered a caveat, noting that currently wind energy is not reliable enough for it to be considered a means of energy security. He said that the national grid had yet to catch up with the amount of energy produced by the OWFs, so much of the energy produced is wasted because the grid

connections are inadequate. This factor was brought up by others when they raised their concerns regarding wind farm policy.

A breakdown of the perceptions of each main benefit is in figure 4 below, and a display of quotes pertaining to each benefit is in figure 5.

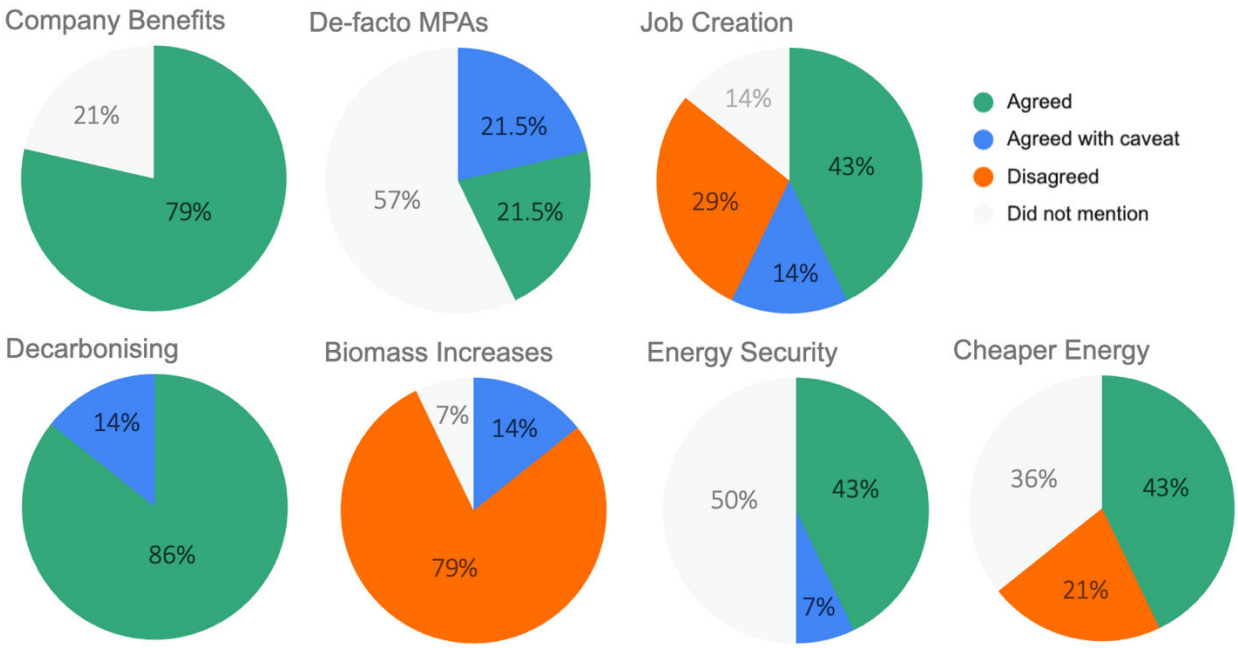
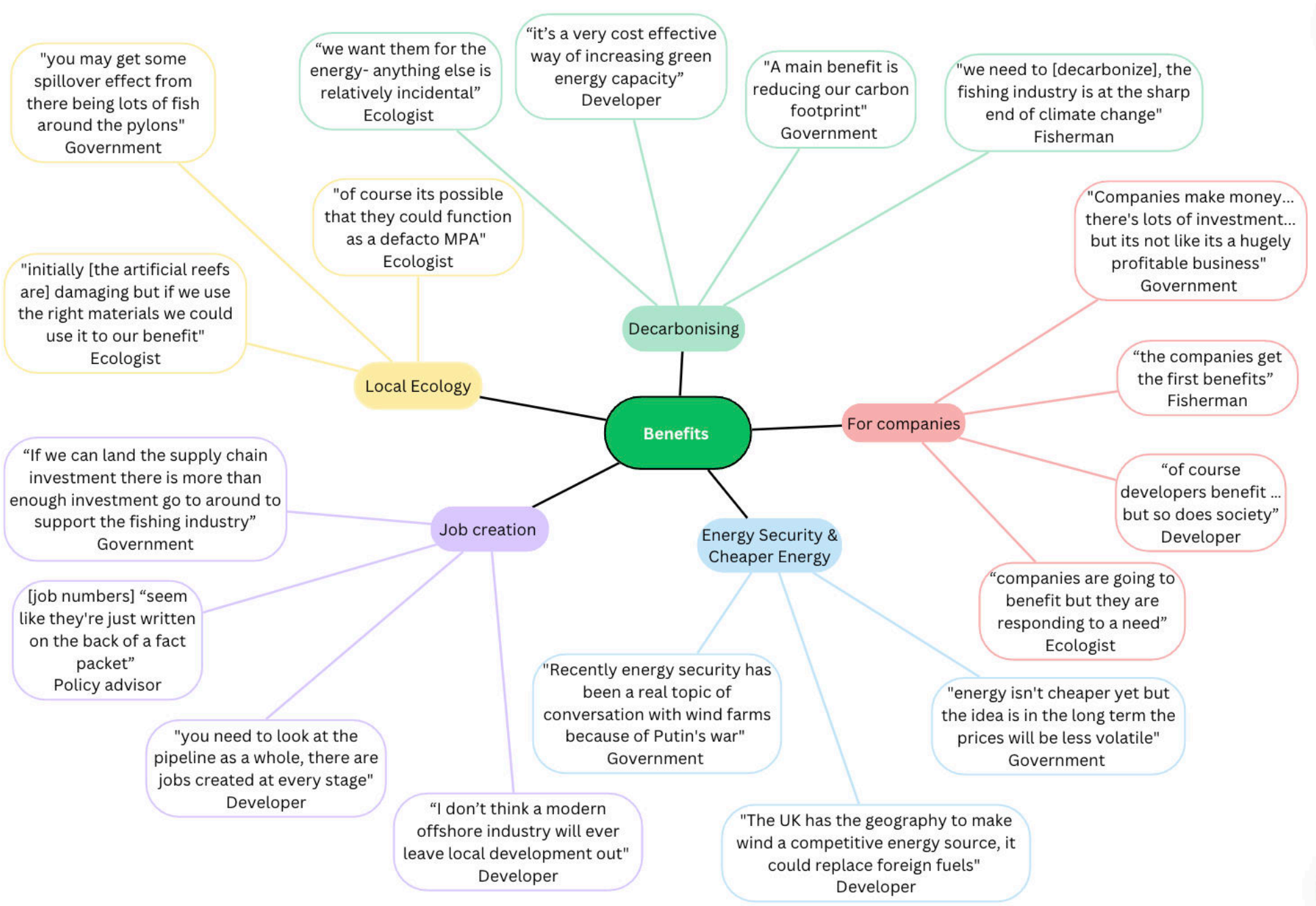



*Figure 4. The breakdown by interviewees' perceptions of each of the main potential benefits. The biomass increases from the artificial reef effect were not seen as a positive, and job creation was the one with the most disagreement. "Agreed with caveat" in this case means that some interviewees mentioned it as a potential benefit but gave reasons why it might not be fully a benefit, or as great of a benefit as others may have thought. Percentages are rounded to the nearest whole number.*

*Figure 5. Display of sample statements pertaining to each of the main benefits.*



*Perceptions of possible costs*

The main costs brought up by the groups were the loss of fishing industry jobs and the potential negative impacts on the environment. All of the interviewed groups acknowledged the possibility of these negative impacts. They disagreed, however, on the relative importance of the impacts.

The first cost is the loss of fishing industry jobs. This was brought up by all fishers (n=4). One fisherman described the issue saying that *"the easiest place to put [OWFs] is where people fish".* Another explained, *"it hurts small boats the most, the cables completely mess up inshore areas where they fish"*. One fisherman summarised the issue saying *"economics and socioeconomics are different. Economically wind farms make sense if you ignore the socio part of it."* He added that the overall contribution of fishing to the GDP is low but that it is important to small communities, and explained that this means they made economic sense for the country but not for small communities. Developers (n=4) and civil servants (n=2) acknowledged these issues but were careful to say that declines in the fishing industry could not be entirely attributed to OWF expansion. One developer said *"the [fishing] industry has been in decline for a while, I don't think you can blame that completely on the wind farms"*. A civil servant echoed this sentiment but reflected on the absence of data, stating, *"the data on where fishermen are just doesn't exist, so it's hard to know if you can blame the wind farms or if [the decline in the fishing industry] is just a trend we'd be seeing anyway"*.

The second main cost is the ecological impact of OWFs. Many people addressed this when talking about the artificial reef effect and the fact that it is not necessarily a positive effect (n=11). General environmental concerns were acknowledged by all individuals (n= 14). One civil servant said, *"What we don't want to do is put 5000 wind farms in the sea and totally destroy the marine environment."* He continued by adding that the lack of data about the initial state of the marine environment made monitoring the impacts difficult. Two developers also said that general environmental concerns were valid but unimportant because the changes were contained within the areas of the OWFs. This a statement that ecologists would vehemently dispute as many made the point that the impacts of wind farms extend far outside their confines.

The impacts of EM frequencies on spawning fish was mentioned by both fishers who were concerned about their fish stocks (n=3), and ecologists concerned about the unknown

long-term effects it might have (n=2) on marine life. One fisherman said *"one real concern is the EM frequencies that come off cables. The EM changes behaviours of adult and larval crab"*. Two developers also acknowledged this and cited efforts to bury cables deeper to avoid the problem, which could potentially cause increase sediment disruption. Noise impacts on marine mammals came up with ecologists (n=2), fishers (n=3), civil servants (n=2) and one developer. Bird impacts were also mentioned by many (n=7), one ecologist said, *"they are flying into an area with big metal fans, and we do see impacts"*. These impacts were also acknowledged by the wind farm developers (n=3). One mentioned their company's effort to mitigate the impacts by creating other areas of conservation for birds even though their companies are not obligated to do so.

Figure 6 provides a breakdown of the respondents' perceptions of each main cost. A sample of statements about each cost is shown in figure 7.

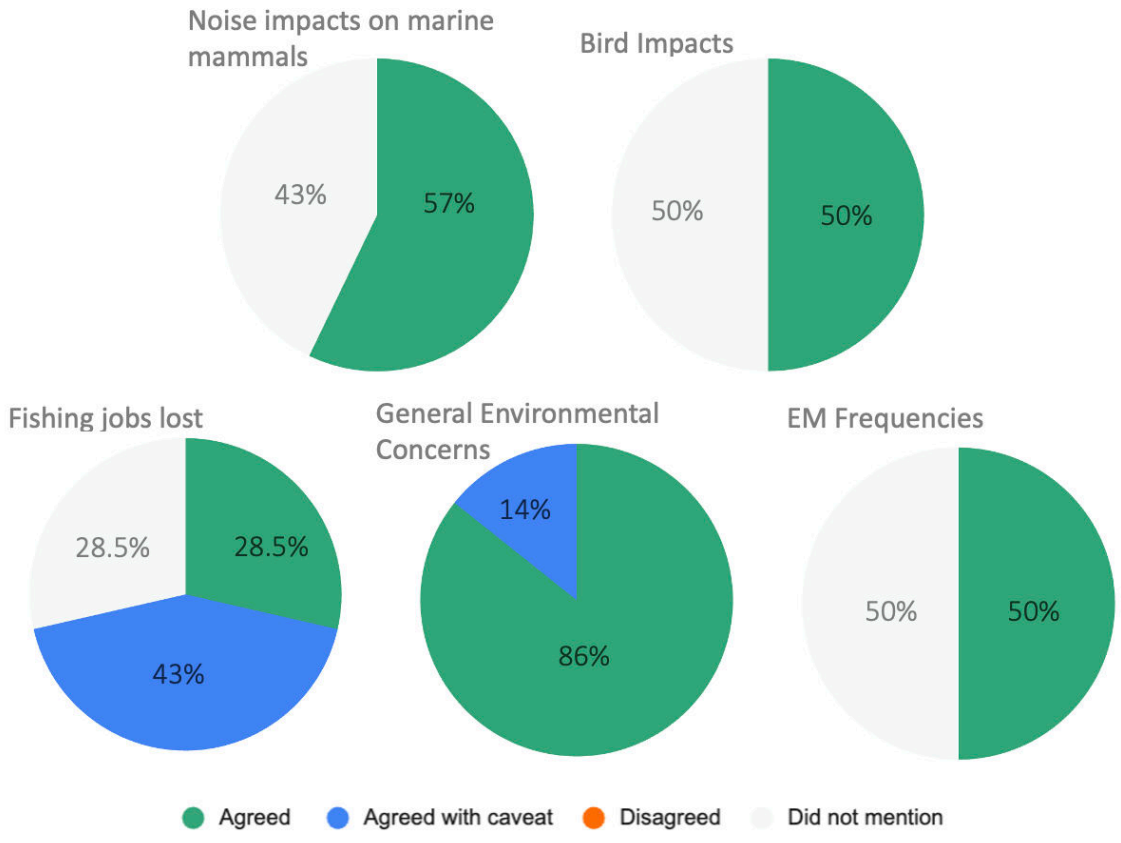
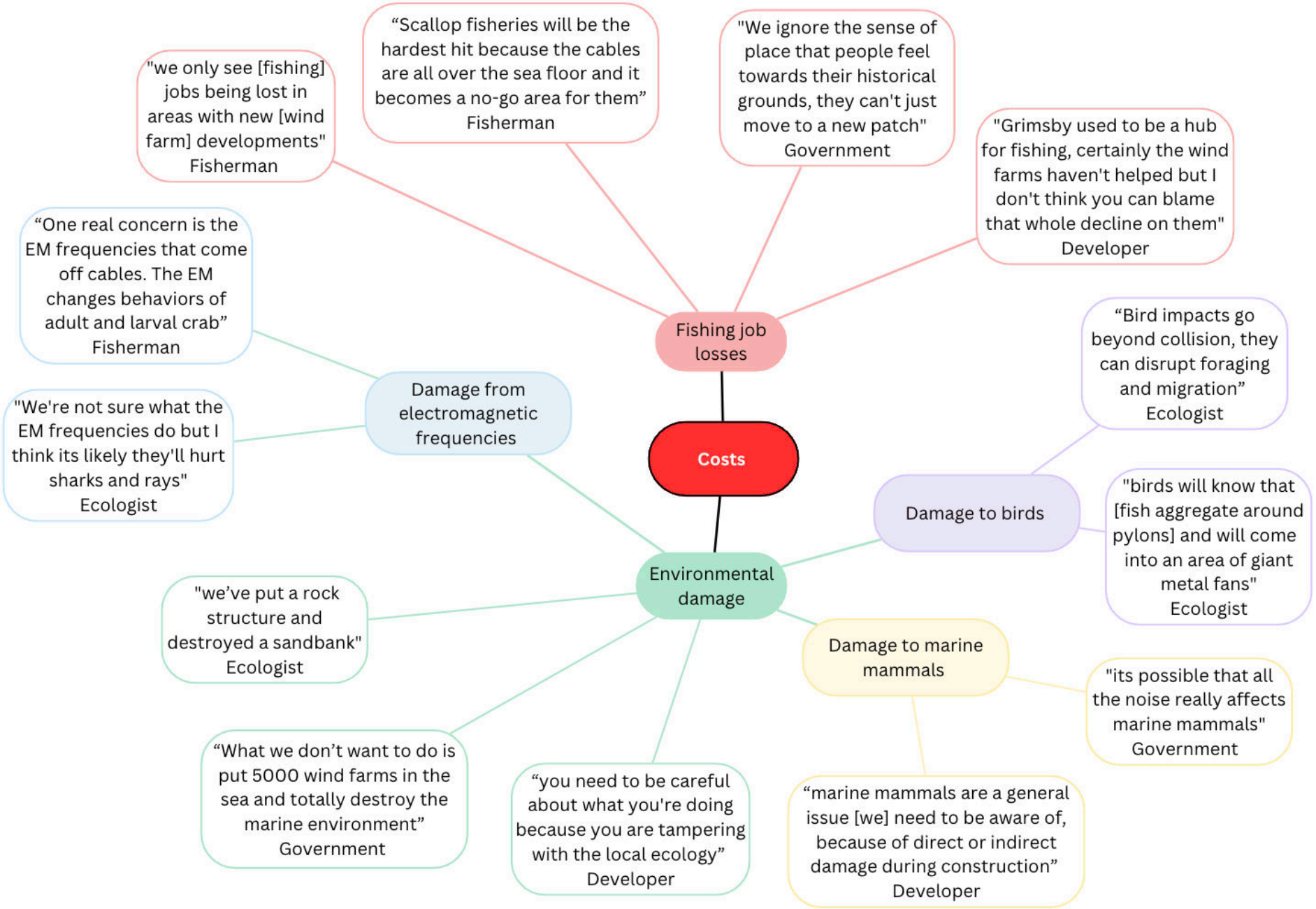



*Figure 6. Breakdown by perception of the four main costs based on a) whether respondents mentioned and agreed that it was a cost; b) agreed but caveated the cost; c) disagreed that it could be considered a cost; d) or did not mention it at all. Other environmental costs were mentioned by less than half of people and are not included in this paper. For most of the costs, no one disagreed that they existed, but some people said that they could not be fully attributed to OWFs (e.g., fishing job loss). Percentages are rounded to the nearest whole number.*

*Figure 7. Display of quotes organised by the main costs mentioned by interviewees. Environmental damage was split into subcategories to display the range of concerns.*



*Policy Concerns*

The majority of interviewees (n=8) raised concerns about the speed of OWF expansion. Wind farm developers (n=4) and civil servants (n=2) were the exception. The developers acknowledged these concerns, stating that while expansion was fast, it was necessary to stop climate change. Another concern mentioned multiple times (n=8) was that the expansion of OWFs was not being met with a similar expansion in onshore infrastructure to handle in the influx in electricity. One civil servant said, *"the way we plan the grid infrastructure is very reactive"* so the grid infrastructure *"has to wait for the investment from the developers."* In terms of decarbonisation, she added "*if we were to pause while we waited for everything to be sorted out, we would be even further behind*".

The lack of marine spatial planning was raised multiple times by ecologists (n=2) and fishers (n=3) and was acknowledged by civil servants (n=3). One ecologist said, *"a lot of the assessments are done just for a [specific] project, but realistically [species] interact with multiple sites so they should be thought of together"*. Fishers (n=4) were frustrated by the lack of consideration from OWFs and new marine protected areas. As one said, *"It's about what the cumulative effect is, and without a [marine plan] no one is considering multiple impacts"*. Another summarised this saying *"government policy up here is 'wind farms are happening, get out of the way' "*.

Three of the developers mentioned another interesting policy point. They said that the UK is one of the only countries in the North Sea (the area in which their companies are present) that values the cheapest bid over other criteria. They explained that this incentivises developers to bring in the cheapest labour and manufacturing costs possible, rather than having pieces locally produced. One civil servant from the Scottish government said that Scotland was working on changing that so that local manufacturing was valued in the bidding process, in an attempt to make sure local investment was prioritised. A breakdown of the perceptions of each main policy point mentioned is in figure 8, and a display of quotes pertaining to each position is in figure 9.

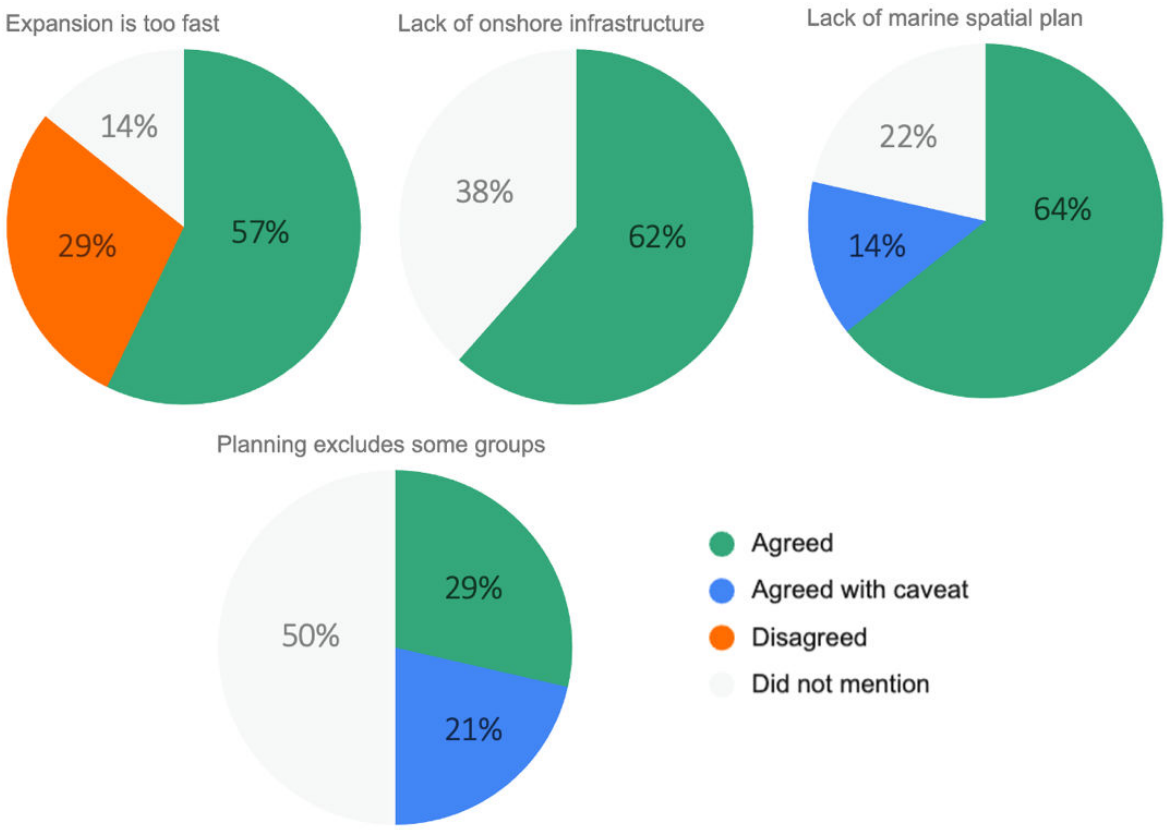
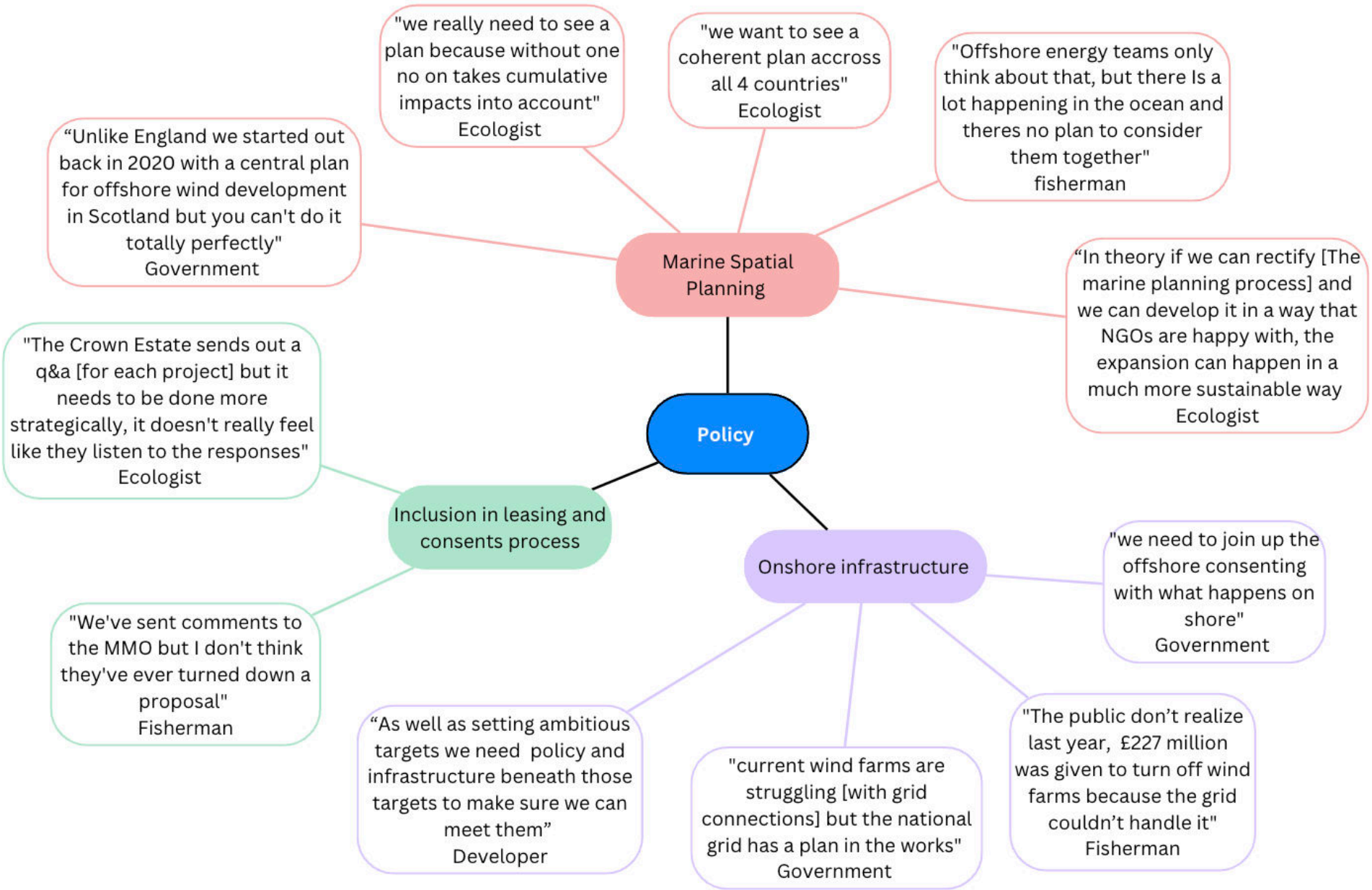



*Figure 8.*
*Breakdown of the four main policy or planning concerns brought up by interviewees. The only area where there was real disagreement was in discussing whether expansion was too fast. In this case "agreed with caveat" means that they said it was an issue but not the main one, or not one that could be feasibly solved. Percentages are rounded to the nearest whole number.*

*Figure 9. Display of quotes pertaining to wind farm and marine policy in the UK.*



## *Discussion*

OWFs are an important tool for the UK government in their progress towards decarbonisation. They could, however, have both positive and negative impacts on the triple challenge of decarbonising, restoring nature, and maintaining human wellbeing. In this study I conducted a brief policy review and scoping review of relevant literature, followed by detailed interviews, to identify and explore these impacts.

In both the policy review and the interviews, I found that decarbonising was held as a high priority for all groups. However, the effects of OWFs on local ecology and local communities were viewed differently. Their wider benefits to society were also valued more highly than I expected. Figure 10 displays an updated version of the triple challenge including wider socio-economic impacts mentioned by interviewees.

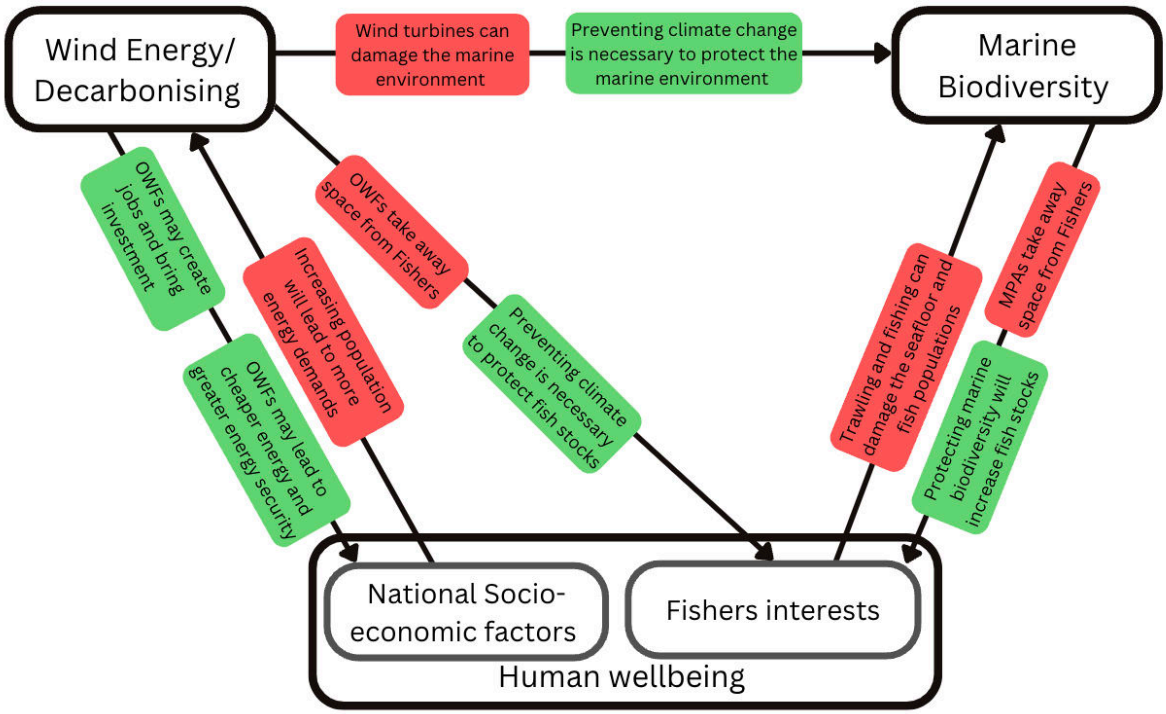



*Figure 10. A display of the triple challenge as it plays out with OWFs, including wider socio-economic factors mentioned by interviewees. Human wellbeing encompasses many factors, and this displays that the same factor (in this case OWFs) can have different impacts on different aspects of human wellbeing.*

## Policy: No targets, non-specific targets, too many targets

The variance in wind energy targets is a particularly interesting finding. There is a clear deadline for full decarbonisation by 2050, but the three different targets (of 30GW, 40GW, and 50GW) by 2030 are very confusing. At best, they targets reflect the lack of clarity and communication between departments setting these targets. At worst the variance displays a lack of actual understanding or an actual plan of what is achievable by 2030. It also makes it difficult to understand the facts regarding the implementation of wind farm policy. The three targets are all ambitious and demonstrate that the UK is serious about building its green energy capacity by 2030. The goals, however, seem arbitrary and unplanned to an outside eye.

The main takeaway from the policy review is that the wind energy targets are more ambitious than those for biodiversity and fisheries. They also have more imminent deadlines. This need to meet statutory goals explains the push to expand wind farms quickly without considering fishermen or local communities. But the long term implications of this gap could have other negative consequences. This policy review also reflects the interviewees' perceptions that OWF expansion is lacking a plan, and does not consider other industries and sectors. The confusion in policies is thus validating and underlines the results of my interviews.

## More Work or No Work? Differing Perceptions about OWFs as Job Creators

The potential for OWFs to create new jobs was one of the most common themes across all the interviews. It was also the issue that prompted the greatest difference in perception across the groups.

Wind farm developers in the interviews and online, regularly cite job creation figures in the thousands (see: Dogger Bank (2023); Orsted (2023)). Even academic literature on the social impacts of wind farm development often lists job creation as an assumed positive impact. So much so, that often the assertion is made without proof or citation, as if it is an obvious fact (for example see discussion of Virtanen et al. (2022))

In this study, interviewees across the sectors agreed that if the green energy sector produced new jobs, it would be a positive outcome. However, from the interviews conducted and the evidence gathered for this study, the assumption of new jobs is just that and for now cannot be verified. Many interviewees held the belief that the statistics on jobs created were misleading because most of the workers were brought in from outside the UK. Others made

the point that any employment was temporary because once OWFs were operational they required very few people. Though the primary purpose of this paper is not to assess the veracity of this perception, I sought out information but was unable to verify it either way. The UK Office for National Statistics (ONS) 2023 report on the Low Carbon and Renewable Energy Economy (ONS, 2021) includes statistics on 'green jobs'. The report estimates that 10,600 full-time equivalent jobs existed in 2021 (ONS, 2021). At the time of writing, however, no estimates were available for 2022 and 2023 because the ONS is undergoing an initiative to define the parameters of what a green job is, and what can be counted as green job creation. Their current data source for these statistics is based on the results of a survey of green energy businesses, clearly deemed not to be reliable enough. New and revised statistics based on new definitions and protocols will be published in 2023 and 2024. The new data will include revised statistics from 2021 onwards (ONS, 2023).

There is a possibility that policies that favour job creation and industry within the UK, could solve the issue of people not feeling that they benefit from any jobs created. Of course, the issue of fishing jobs lost is not solved by creating more local jobs, but the point made by developers about the UK favouring cheaper bids is interesting. The fact that the Scottish government is already making changes is also notable and should be monitored to see if local perceptions change as local labour and manufacturing is favoured.

## Environmental impacts: What we know we don't know.

There was significant agreement in perceptions across the key informant interviewees regarding the environmental impact of OWFs.

In existing literature, the artificial reef effect has been studied extensively (Bergström et al., 2014; Degraer et al., 2020) and this focus was matched in the interview responses. All individuals recognised that OWFs would have a local environmental impact. Although other issues like EM frequencies were mentioned by some respondents, the impact of the wind farm bases on local ecology was the most commonly noted issue. The ecologists and researchers especially mentioned the artificial reef effect frequently.

Though there was a consensus that OWFs had a net negative environmental impact, both the research and some interviewees suggested that there can be means of mitigating this with some positive outcomes. One ecologist explained that if we assume the damage from the

OWFs is a given and consider this as a baseline, there may be ways to make artificial reefs work for other goals. There is research supporting the notion that artificial reefs can assist in achieving conservation outcomes (Tickell et al., 2019). A report from the Royal Society for the Protection of Birds (RSPB) also highlights means of ensuring that OWFs work synergistically with environmental goals, including requiring site-specific compensation and monitoring of biomass to gather information on the artificial reef effect and its utility in increasing biomass in depleted areas (RSPB, 2022).

The long-term impacts of artificial reefs on OWFs are still very poorly understood. Most studies have been limited to one wind farm and have not explored the connectivity between OWFs. Degraer et al (2020) note that artificial reefs may allow some species to expand their ranges because the pylons essentially create a new intertidal zone by having a structure that is close to the surface in the middle of the ocean. They suggest that as OWFs expand, the increase in these new environments could have greater impact than each farm individually, as it could create a series of new connected habitats.

The potential benefits of the artificial reefs should also be considered when reviewing decommissioning policies, especially given the current rule that every structure must be removed in its entirety. This is particularly important given that even if healthy marine communities are created based on the artificial reefs, as policies currently stand, they would be destroyed once the OWF is decommissioned.

## Planning and Policy Concerns

Policy concerns were one of the most interesting results because, in answering questions about policy, people also revealed their true primary concerns.

Most of the discussions around marine spatial planning (MSP) focussed on ensuring that cumulative impacts were accounted for. There was not much concern about leaving areas designated for OWFs untouched and protected. This indicates that, people acknowledge that wind farms will have some impact on marine life. In fact, even for fishermen and ecologists, their primary concern was that the process of accounting for those impacts was inadequate.

Developers and civil servants also raised the issue of marine spatial planning frequently but tied it in with onshore infrastructure. This again reveals that they know that there are issues

with the current process for marine spatial planning and with offshore wind development plans, even if they currently benefit from the push towards OWFs.

In effect, the different groups agree on the ideal policy scenario but disagree on the feasibility of that scenario. Members of all groups acknowledged that the rush to decarbonise cannot wait for a perfect plan to be in place because there is no such thing as a perfect plan, and the climate crisis is imminent. One civil servant pointed out that Scotland has had a marine plan in place since 2015, and that they are currently creating a new one. Further research about the effectiveness of their marine plan could be valuable, including the effect of such the plan on local communities' perspectives.

The cohesion of land and marine planning is another interesting question that has been studied in literature for decades (Smith et al., 2011). The economic feasibility of matching the offshore wind expansion with onshore grid expansion is unclear. Currently, according to one governmental interviewee, the grid relies on investment from the developers and therefore generally lags behind the developments. It now seems obvious that the UK should have invested earlier in grid infrastructure to go along with OWF expansion, but the hefty price tag associated with the infrastructure may have been a political hold-up, especially before they could show any energy had been generated.

The policy question overall is extremely important because policy dictates how different aspects of the triple challenge evolve. Without policy that considers the interactions between the three sides of the triple challenge, at least one side will be inevitably excluded. There could be a situation where wind farms are pushed to expand so quickly that they hurt the UK's chances to meet its marine biodiversity goals. Alternatively there could be a situation (much like recent decades) where short term human well-being is prioritised to the detriment of wind farm expansion and the climate at large. Situations like the latter have happened before with onshore wind expansion being halted due to local community complaints (Devine-Wright et al., 2017).

## Future Directions: more research, more to consider.

This topic is incredibly current. Policy and research that will change the way this topic is viewed is being written and published regularly, and as more information becomes available, more questions about the real-term impacts will be answered.

As mentioned above, more research is needed on the actual job numbers created by new OWFs, and the economic activity they may bring to the areas where they are built. Socioeconomic impacts outside the fishing industry would also be interesting to investigate, tourism in coastal towns for example may be affected by OWFs. Environmental research to understand long-term impacts is also necessary and should inform decommissioning policy in the future. In general, better monitoring of OWF impacts on communities and local environments is necessary to properly understand this issue going forward, and to monitor the UK's progress towards their environmental goals. Similar studies are also necessary to understand the environmental effects of new wind farm technologies like floating OWFs that were not addressed in this study.

The examination of the social and environmental impacts of the full lifecycle including manufacturing and disposing of OWFs was outside the scope of this study. However, these factors should be considered when assessing their full impacts. They are notoriously difficult to recycle and though there are some efforts to recycle them, many have ended up in landfills (Martin, 2020). There are also concerns about the minerals and metals necessary for the construction of the turbines. The conditions under which these minerals are mined and the impacts on local communities including the impact on children must also be addressed (Church, 2018). Other environmental impacts from the materials needed for wind turbines were explored by Rueda-Bayona et al. (2022). The costs like the carbon emitted from concrete production, the waste from plastic needed for the blades, and the mining of other metals needed for the cables and structure, should all be considered in an impact assessment.

It is also possible, if not likely, that the demand for metals needed in turbines and batteries could lead to conflicts between countries, similar to how fossil fuel demands have sparked conflicts for decades (Church, 2018). The demand for minerals like graphite and cobalt is expected to more than quadruple by 2050 (Hund, 2020). Cobalt is already associated with child slavery in the Democratic Republic of the Congo, and has been called the "blood diamonds of this decade" (Church, 2018). Blindly pushing for decarbonisation without considering these impacts could aggravate them and lead us to repeat mistakes made with fossil fuel demands (Church, 2018).

These issues are clearly related to the impact of OWF on many scales (figure 11). Local, national, and international assessments need to be tied together to understand OWF impacts comprehensively.

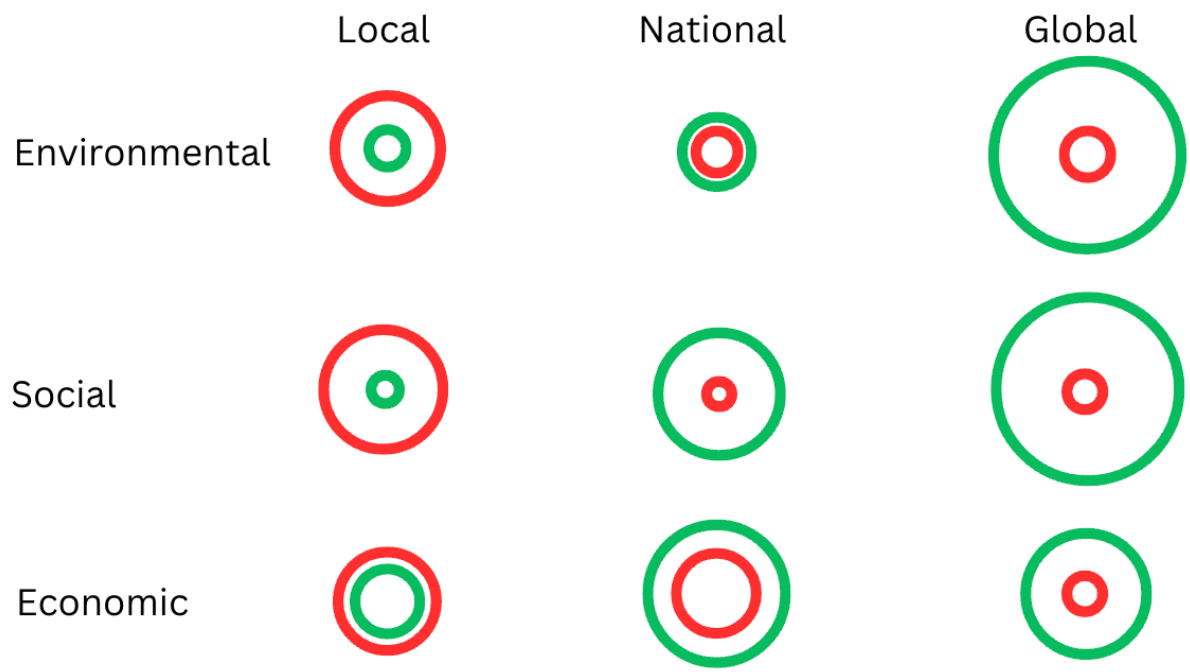



*Figure 11. A rough schematic of the relative size of the costs and benefits of OWFs at each scale. Red circles indicate the rough size of costs, green circles indicate the rough size of benefits. Shown here to demonstrate that at a global scale the benefits outweigh the costs of OWFs, but on a local scale the costs outweigh the benefits. This figure is for the UK but could be modified to show other local impacts. Adapted from Balmford and Whitten (2003).*

## *Conclusion*

There are a few important conclusions to draw from this study. The first is that the policy base for the expansion of wind farms is disorganised. The lack of coherent targets and comprehensive approaches likely contributes to the frustration that many stakeholders exhibited when talking about the future of wind farms. It is clear that everyone involved wants to decarbonise, and most want to do it in a way that is sustainable for local communities. However the lack of integration between land and marine planning is making the shift more difficult than perhaps it needs to be.

Separating energy goals, socio-economic policies, and nature priorities is a recipe for chaos. This study shows the need for a systematic and ongoing multistakeholder approach to ensure that negative environmental and community impacts are mitigated early on. We need to make sure that our efforts to save the planet are not disrupting and destroying environments and communities that people and other living beings need to thrive.

The changes that lead to a better offshore wind development plan are not obvious or easy. We do need to decarbonise, and we need to do it fast, however if we are planning to develop a new global energy system based on renewable energy, it is worth making sure that it does not face the same pitfalls as the previous one.

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