WORKSHOP ON SOCIO-ECONOMIC IMPLICATIONS OF OFFSHORE WIND ON FISHING COMMUNITIES (WKSEIOWFC)

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i Executive summary

Common, consistent, and accepted frameworks for defining and quantifying the socio-economic impact of offshore wind on fisheries are urgently needed in Europe and in the United States of America. What information do we need to describe the socio-economic, socio-environmental, and socio-cultural complexities involved in fishing fleet behaviour and shore-side activities?

The aim of the ICES Workshop on Socio-Economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC) was to develop a framework to define the socio-economic effects and impacts of offshore wind on fishing behaviour, fishing communities and coastal communities more broadly. The workshop allowed us to describe, summarise and illustrate the environmental, economic and cultural effects that offshore wind development has on fisheries.

Key results are preliminary conceptual models of cause-and-effect relationships, evidence and data gaps, reflections on the assessment of the cumulative impact from offshore wind on the fishing sector and fishing communities as well as identified perceptions of similarities and differences between European and USA regions.

The workshop demonstrated the importance of improving our understanding of the socio-economic implications of offshore wind and fisheries interactions and highlighted the benefit of coordination with other ICES working groups focussing on topics relevant to offshore wind development and fisheries. Improved understanding can be used to foster the exchange of information and collaboration in addressing science questions, and to support decision-making. These activities are considered to have a very high priority on a global level, especially as wind energy development technology evolves and the wind industry continues to require additional ocean spaces.

ii Expert group information

Expert group name	Workshop on Socio-economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC)
Expert group cycle	workshop
Chairs	Tara Hooper, UK
	Annie Hawkins, USA
Meeting venue and dates	15-17 March 2021, online meeting (50 participants)

1 Background information

The advancement of offshore renewables such as offshore wind farms (OWF) or wave and tidal stream energy devices is a response to increasing energy demands and a key pillar in the global transition to a carbon-free power sector (GWEC 2019). In 2018, the worldwide installed capacity of marine renewable energy was dominated by offshore wind, which summed up to 23.1 GW with a European contribution of roughly 79% (Stelzenmüller *et al.* 2020) and a US contribution of 30MW. The European development corresponds to 5,047 grid-connected wind turbines across 12 countries (www.windeurope.org) with a current average distance to shore of 59 kilometres and an average water depth of 33 metres (Stelzenmüller *et al.* 2020). In Europe, the development of offshore renewables varies greatly among the different European sea basins (Baltic Sea, North Sea, Atlantic, Mediterranean Sea and Black Sea). Northern European countries such as the UK, Germany, Denmark, Belgium, the Netherlands, and Sweden currently have the highest numbers of installed OWF and turbines (www.oceanenergy-europe.eu). Further, a reduction of greenhouse gas emissions by at least 55% by 2030 (compared to 1990); (https://ec.europa.eu/clima/policies/eu-climate-action/2030_ctp_en), a target adopted under the global Paris Agreement in 2015 and its wider 2030 climate energy framework, is to be implemented via national climate action plans (European Commission 2015, 2018; Europêche 2020; Stelzenmüller *et al.* 2020). A large share of this (at least 32%) will be achieved by the EU Member States through renewable energy (Stelzenmüller *et al.* 2020). The goal for offshore wind in Europe is for between 230 and 450 GW by 2050 to assist in the delivery of climate neutrality by 2050 (European Commission statement 2020). According to the International Energy Agency (IEA), offshore wind is set to become the main source of power generation in Europe by 2042. In the United States, offshore wind development is set to expand across the Atlantic, Pacific, and Gulf of Mexico with recently announced targets of 30 GW by 2030 and 110 GW by 2050 (White House Statement). As a result, the implementation of offshore marine renewables will speed up the race for space in the already heavily used offshore and coastal waters across the world (Halpern *et al.* 2019, Stelzenmüller *et al.* 2020). In the United States, ongoing and planned actions are expected to result in the installation of over 2000 turbine foundations that "would increase the risk of highly localized, periodic short-term or long-term, moderate to major impacts on commercial fisheries" (Bureau of Ocean Energy Management, 2021). In addition, proposed U.S. development will result in major adverse impacts on fisheries scientific research and surveys that "may result in more conservative quota and effort management measures" (Bureau of Ocean Energy Management, 2021). Some fisheries could be at risk of losing access to traditional fishing grounds due to safety requirements imposed by OWF development leading to potentially decreased landings. Existing knowledge on the impact of OWF on fisheries is focused mainly on ecological impacts, assessments of economic and socio-cultural effects are lacking in recent empirical studies (Stelzenmüller *et al.* 2020). Further, current publications on impacts often neglect assessment of proposed future expansions of OWF (Stelzenmüller *et al.* 2020).

No common, consistent, and accepted framework for defining and quantifying socio-economic impacts exist in Europe nor the United States. The Working Group on Offshore Wind Development and Fisheries (WGOWDF) focuses on the interactions between fisheries and offshore wind energy. While there are distinct differences in the scale and scope of fisheries between the North American and European wind development areas, there is an opportunity to identify common issues and promote research to address these issues. The aim of the ICES Workshop on Socio-economic Implications of Offshore Wind on Fishing Communities (WKSEIOWFC) was to develop a framework to define the socio-economic effects and impacts of OWF on fishing behaviour, fishing communities, and coastal communities; identify research gaps and lessons learnt; and generate recommendations for research to address these issues. Results feed directly in Term

of Reference (ToR) A "Review and report on fishing industry interactions with offshore wind development and document lessons learnt including the effects on the distribution of fishing operations."

2 Workshop Introduction

The aim of WKSEIOWFC was to develop a framework to define the socio-economic effects and impacts of OWF on fishing behaviour, fishing communities and coastal economies. This report provides a general summary of the workshop, and primarily describes the activities that took place. Some preliminary results are presented to illustrate some of the outcomes and the input received from workshop participants; as such, some statements represent subjective and, at times, differing viewpoints. More comprehensive reporting and analysis of the data generated will occur as part of the deliverables for ToR A of the WGOWDF. The list of participants and the workshop resolution are given in Annexes 1 and 2.

Due to current challenges resulting from the Covid-19 pandemic, the workshop was conducted remotely using Zoom software (https://zoom.us/zoomrooms/software). Participants were requested to prepare for the workshop in order to use the workshop time most effectively. As the workshop received support from other ICES working groups working on the topic of OWF development, participants were invited to watch the recorded presentations from WGSOCIAL, WGECON, WGMARS, WGMBRED, and WGMPCZM (see Annex 3) and to take part in a discussion round with the presenters. Further, they were asked to write a short bio about themselves in order to shorten a lengthy round of introductions and still give participants the opportunity to network with each other. Finally, they were invited to take part in a pre-workshop survey to identify the key issues for OWF and fishery interactions (see Section 3).

The workshop focused on three themes relevant to the interaction between fisheries and OWF:

1. Environmental – how both ecological change and the presence of infrastructure affect fishing activities;
2. Economic – the economic implications of changes in fishing activity (at the level of individual businesses, the industry and more widely); and
3. Social/Cultural – the wider interactions between fishing, coastal communities and society, and how these might be affected (Figure 1).

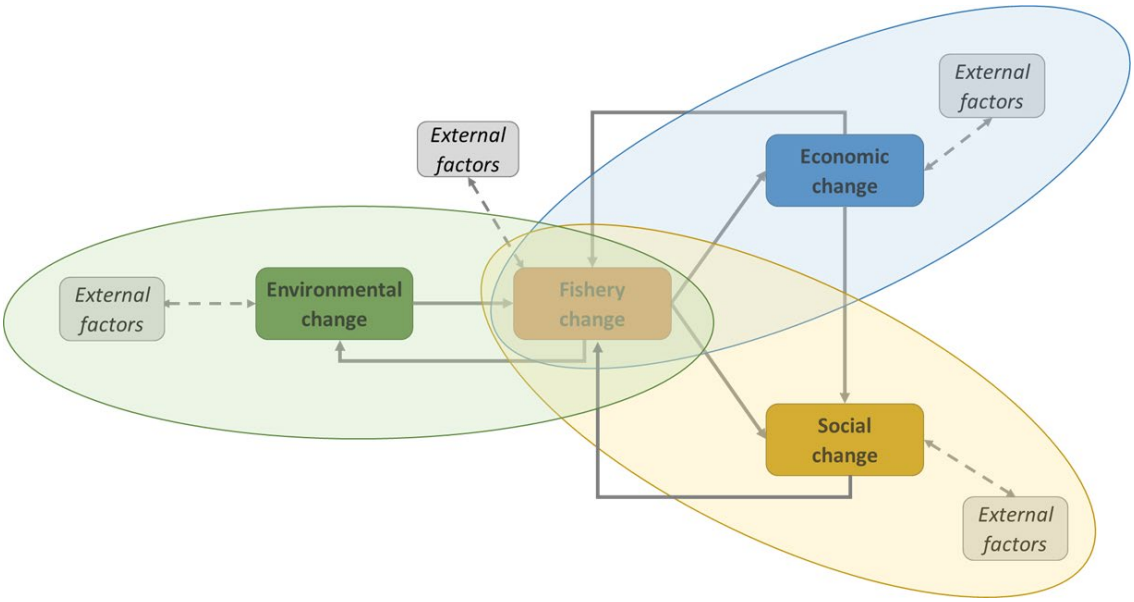

Figure 1. A conceptual representation of the interactions between environmental, fishery, economic and social/cultural changes, and how these different elements were partitioned into the three main workshop themes.

To ensure everyone could participate actively, these themes were discussed in small group break-out sessions that ran in parallel during Days 1 and 2 of the workshop (see Section 4). Across the break-out groups and the wider workshop, the following objectives were pursued:

- To determine the routes by which the development of OWF could cause change in fishing practices;
- To understand the implications of this behaviour change at individual, community and societal levels;
- To determine the extent, and sources, of current evidence;
- To identify methods for filling data gaps;
- To develop recommendations for generating evidence to support management decisions related to OWF and fishery interactions.

The workshop also included plenary sessions for feedback and full group discussion (see Section 5). This included discussion of additional cross-cutting topics, particularly around similarities and differences between the European and US contexts, as well as evidence and data gaps and introducing the need for better understanding of cumulative socio-economic impacts. Further, the final session of the workshop during Day 3, to discuss recommendations (see Section 6), was opened up to a wider audience/guests. At the start of the workshop and the open session with guests, moderators drew the attention to the ICES Code of Conduct and the ICES Conflict of interest statement.

3 Pre-Workshop Survey

In order to use the workshop time most effectively, we invited our participants to take part in a pre-workshop survey to identify the key issues for OWF and fishery interactions, and also to place these interactions in the context of other factors affecting both industries. The survey was conducted using the Mentimeter software (https://www.mentimeter.com/). The survey was open for about two weeks (24.02–08.03) and focussed on three interrelated topics, namely socio-economic, socio-cultural and socio-ecological topics, that are covered by multiple questions in three separate sections.

The aim of the questions from the environmental dimension of impact was to gather initial opinions on what changes associated with OWF (both ecological and from the presence of infrastructure) may affect fisheries. The focus was on capturing the perspectives of participants to questions on: 1) What are the environmental changes associated with OWF that could affect individual fishing behaviour?; 2) How might fishing activity change in response to these environmental changes?; the participants were also asked to provide suggestions relating to 3) What other environmental factors, not connected to OWF development, might lead to fisheries changes (e.g. climate change)?

In order to define the economic changes for the fishing sector due to OWF, the questions were structured in such a way that the effect on a single individual was considered as well as the effect on the wider sector and value chain: 1) How could the costs and income generation opportunities for individual boats change in response to OWF development?; 2) What changes in costs/income generation opportunities could occur at the scale of the fishing sector?; 3) What are the potential economic consequences for the wider value chain onshore?; and 4) What other economic changes for the fishing sector are impacting fisheries that are important to understand within the context of OWF development?

The cultural dimension of impact was dedicated to discussing the consequences for coastal communities and society: 1) In what ways is fishing important to coastal communities and wider society?; 2) What types of changes in fisheries would affect those interactions with coastal communities and wider society?; and 3) Apart from OWF development, what else might be affecting seafood consumption and public perceptions of fisheries?

Preliminary Survey Results

From our pool of 50 workshop participants (i.e., experts from the fields of natural and social science (e.g., oceanography, biology, economics, anthropology) and governance (e.g., policy, nature conservation, and administration), altogether 36 participants took part in our pre-workshop survey and sent in responses. Each participant could submit multiple responses to each of the survey questions (leading to more individual responses than the number of participants). The responses were then coded (following qualitative content analysis principles) to identify themes within them, and define uniform terms to facilitate subsequent analyses. The number of responses and themes for each of the survey questions are summarised in Table 1. The outcomes of the pre-workshop survey were presented to participants in a series of graphs, which ranked each theme according to the number of responses related to it (see the example in Figure 2, and the complete set in Annex 4).

Table 1. The number of respondents, individual responses and main themes within those responses for each of the pre-workshop survey questions.

Workshop theme	Question	Number of respondents	Number of individual responses	Number of main themes within the responses
Environmental	What are the environmental changes associated with offshore wind farms that could affect individual fishing behavior?	36	122	29
Environmental	How might fishing activity change in response to these environmental changes?	36	71	23
Environmental	What other environmental factors, not connected to OWF, might lead to fisheries changes?	36	70	15
Economic	How could the costs and income generation opportunities for individual boats change in response to OWF development?	36	86	13
Economic	What changes in cost/income generation opportunities could occur at the scale of the fishing sector?	33	51	15
Economic	What are the potential economic consequences for the wider value chain onshore?	34	44	22
Economic	What other economic changes, not connected to OWF development, are impacting fisheries?	33	83	16
Cultural	In what ways is fishing important to coastal communities and wider society?	33	124	14
Cultural	What types of changes in fisheries would affect those interactions with coastal communities and wider society?	28	57	14
Cultural	Apart from OWF development, what else might be affecting seafood consumption and public perception of fisheries?	33	97	15

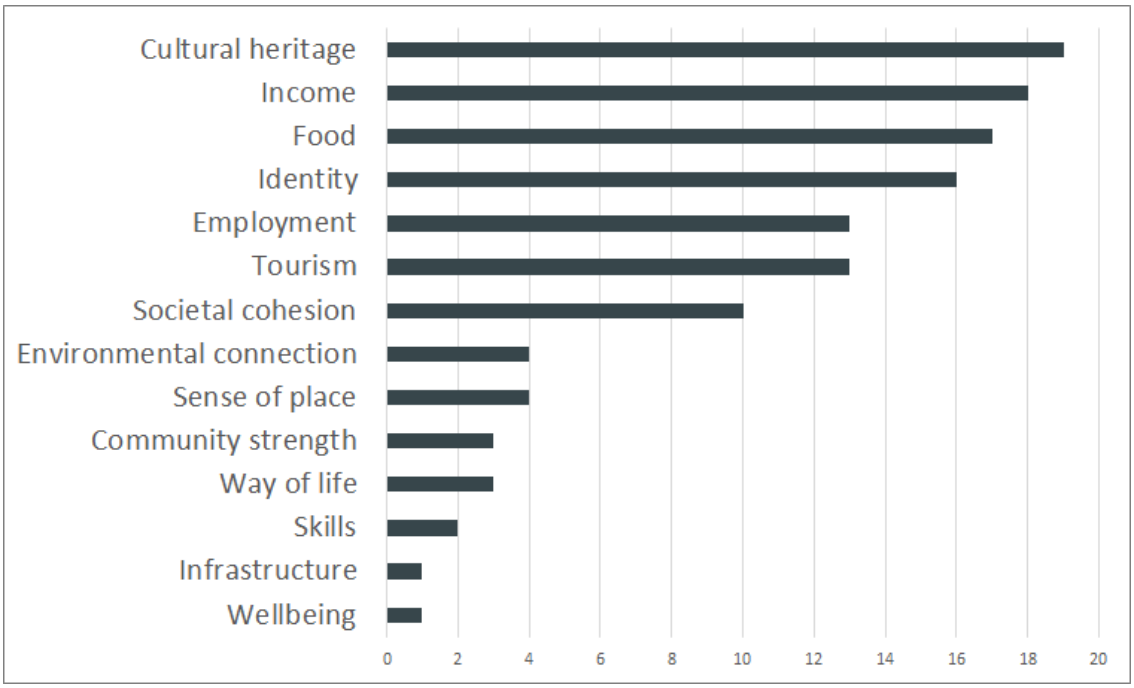

Figure 2. The number of responses in each of the main themes identified within responses to the question "In what ways is fishing important to coastal communities and wider society?"

4 The World Café

All participants were prompted to indicate which sessions they expected to attend and their relative preference for the three main workshop themes. Based on that, participants were allocated to break-out groups ensuring that the groups were made up of an equal number of representatives from the US and European regions. The workshop chairs further dictated the order in which they join the discussion about each theme. All break out group discussions were moderated and recorded. After welcoming the participants, the moderator and the participants introduced themselves although all material was handled anonymously. After 90 minutes of discussion and a brief summary of what was said, the moderator ended the discussion.

The main activity that took place during the break-out groups was brainstorming participants' perspectives on the linkages between different factors to illustrate how changes in the environment could lead to changes in fishing behaviour and hence implications for wider society and the economy. These linkages, hereafter described as "cause-effect relationships" were mapped to provide a visual summary of the multiple factors involved and their interdependencies. The supporting narrative from the discussions undertaken during the mapping exercise was the key information collected during the workshop. Details from these discussions were captured as notes attached to the individual 'nodes' within the maps and the connections between them, within the Mental Modeler software (http://www.mentalmodeler.org/) that was used to create the maps.

4.1 Preliminary results from the breakout groups

Figures 3–5 illustrate, respectively, the maps created in the environmental, economic and cultural break-out groups, and highlight the complexity and interconnectedness of the issues under discussion. These maps are not intended as a final output, but to support the ongoing work within ToR A of the WGOWDF. The summaries below reflect the comments made at the time by workshop participants.

4.1.1 Environmental theme

The environmental subgroup considered both ecological and physical changes that are expected to occur with OWF in relation to the potential effects on fishers. This meant that there were two main perspectives: the change to the fisheries resource species (e.g. distribution and abundance) and access to the fishing grounds. Regardless of perspective, the focus was centred on the effects on an individual fisher. We asked participants to offer suggestions on electronic post-it notes using Jamboard (https://jamboard.google.com) and supplemented this with information summarised from the pre-workshop survey questions. We looked for themes and topics within the themes to begin mapping linkages and interconnections/ interdependencies.

Emergent themes were the physical presence of the wind turbine(s), scour protection and any mooring (particularly relevant for floating offshore wind - which is seen as a potentially big cause for concern given the areal extent over which catenary mooring systems will exclude fishing). The physical presence is seen by some workshop participants as leading to varying degrees of displacement of fishers because of safety issues, insurance questions or legislative exclusion (as occurs in some European countries) - issues that link with the other subgroups. The presence of an OWF is expected to change local abundance and distribution of fish, potentially altering target

fisheries species availability. Participants also recognized that there may be new opportunities for fishers presented by OWF development. The subgroup also discussed the biological effects (e.g., habitat alteration, spill-over, productivity change, larval considerations) and more broadly non-biological effects (e.g., bathymetry, turbidity, sedimentation, cold pool). These themes feed into changes to sub-topics such as stock, abundance, and distribution. Cause-effect relationships and linkages between the themes along with their specific sub-topics were discussed and mapped. The groups then considered potential fishing activity changes in relation to these expected environmental changes affecting the fisheries resource species. Spatial and temporal effects on the fishing activity emerged as key aspects with a very clear differentiation between fixed and mobile gear and the different consequences (for example, in terms of catch per unit effort (CPUE), the types of vessel and gear that could/couldn't be used, transit times to fishing grounds and loss of fishing grounds). Finally, the participants highlighted the socio-economic effects - thereby highlighting the links to the other two subgroups.

Towards the end of the subgroup sessions other factors not directly connected to OWF, but which could affect fisheries, were offered. These centred on wider effects, such as climate change impacts, water quality changes, other ecological changes (such as non-native species, predator-prey impacts, food web trophic changes), emerging diseases, cumulative effects and other offshore activities, changes to prices and costs and management of the coastal and offshore environment, and longer-term COVID effects. Participants recognized that this is a complex and multi-faceted topic and should focus on the fishers set within the context of existing governance, appropriate timescales, data considerations (i.e., scale, accuracy, data availability and modelling into the future) and the wider environmental changes (such as climate change).

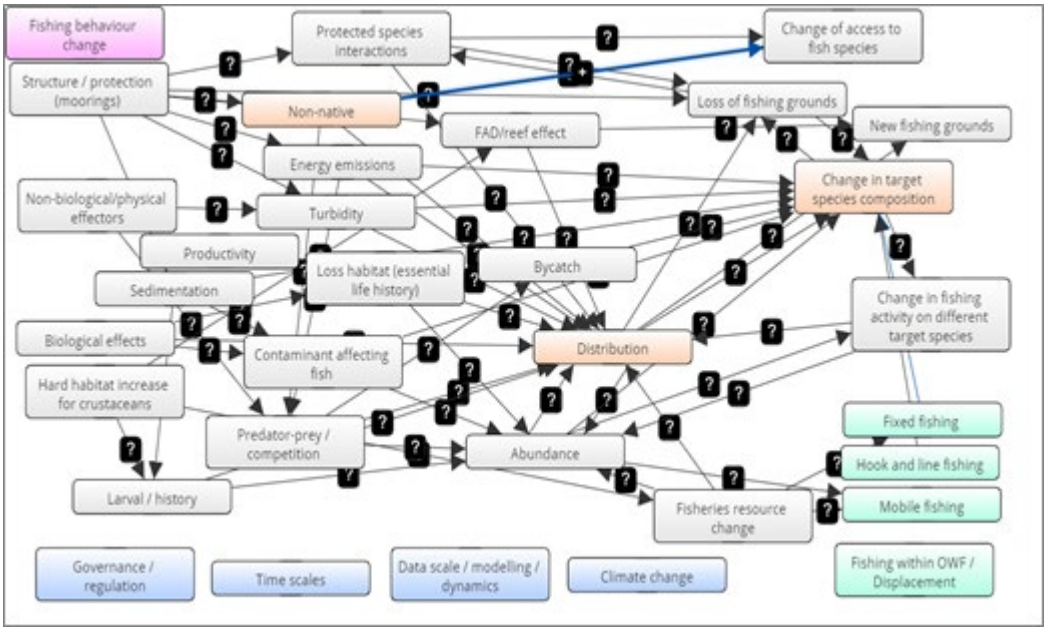

Figure 3. Cause effect maps describing interrelationships between changes in fishing behaviour, OWF development, and environmental impacts.

4.1.2 Economic theme

The economic subgroup discussed the effects on individual fishers, fishing sectors and the wider value chain. The starting components for the indicator mapping exercise originated from the most common themes mentioned in the economic pre-workshop survey questions. Observations on potential access to fishing grounds within OWF areas, potential displacement, and how these link to catch efficiency, costs, business risk and uncertainty, adaptability and government frameworks were key portions of the session. Gear types (fixed vs mobile) or the type of fishing ("metier") can impact the cause-effect directions , as some participants noted that mobile gear may lose access to OWF based on spatial needs and operational risk. Insurance availability and cost could lead to OWF areas acting as de-facto closures, thereby making it an important component in the cause-effect models related to access to fishing grounds. Fishermen adaptability is dependent on government frameworks and fishermen's ability to switch target species and gears. This also connects to the (capital) expense of new gear and permits. The cause-effect mapping exercise highlighted the complexity in capturing how temporal, spatial and regional differences could change the direction of the effects within the model. For example, on a temporal scale, CPUE could decrease during the construction phase of an OWF, then increase during the operation phase. Coastal fisheries experience different effects than offshore fisheries. Regional differences within Europe, within the U.S., and between Europe and the U.S., as highlighted in Section 5.1, also play a significant role There are also differences in connections based on the type of mooring used in offshore wind development (e.g., fixed vs. floating).

The final economic subgroup session was focused on the wider industry and value chain relationship. Connections between cause effect model components were solidified. For example, effort and catch efficiency connect to fleet reduction, loss of employment opportunities, and market changes. The footprint and cumulative scale of OWF development was identified as an important factor for consideration.

The second and third sub-group discussed relevant existing economic data, identifying data gaps and best practices to rectify those gaps. The cooperative approach used in the U.S. surfclam fishery economic model (Munroe *et al.*, in prep.) and the Fishermen's Knowledge Trust (https://roda-fisheries.org/portfolio/fisheries-knowledge-trust/) were identified as good examples of more inclusive fisheries assessments and data sharing frameworks. Data deficiencies (e.g., lack of vessel monitoring system data, VMS) for capturing displacement and differentiating when vessels are transiting rather than fishing (viable fishing areas vs. pass-through areas) were identified as data gaps. Possible best practices included using small trackers to reduce VMS deficiencies and building trust between the fishing industry and fisheries liaisons to cooperate in collecting data and understanding fishing operations, although these approaches include their own limitations or challenges.

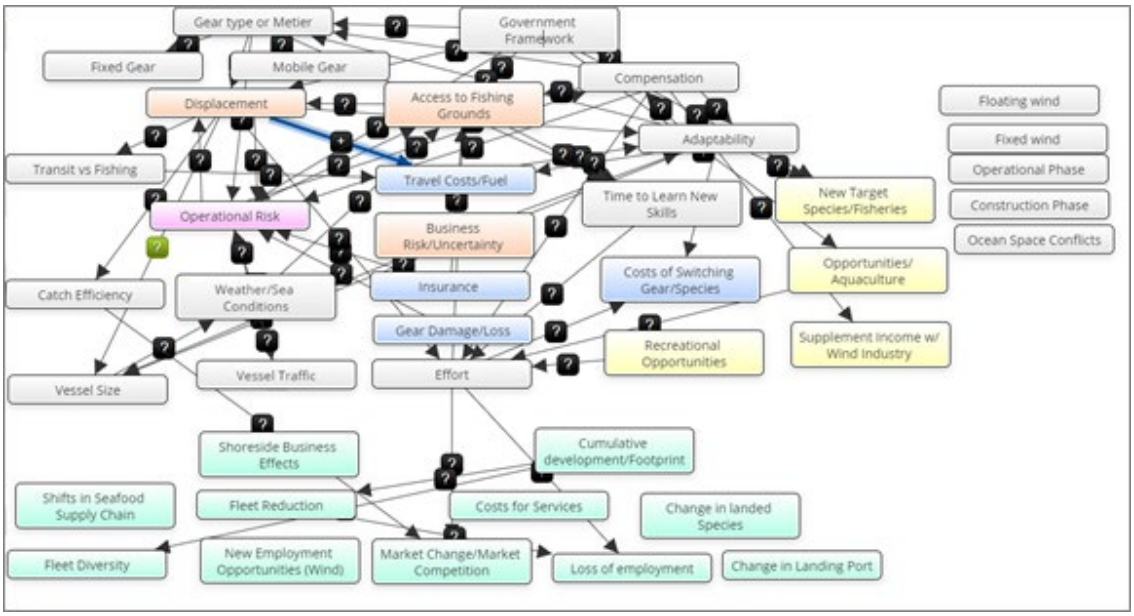

Figure 4. Cause effect maps describing interrelationships between changes in fishing behaviour, OWF development, and economic impacts.

4.1.3 Cultural theme

The wide-ranging discussions within the cultural theme included observations on management, governance and the perceived distribution of power, as well as how this links to the creation of social capital through the organisation of community and industry networks. Resilience and the willingness or ability of fishers and the community to adapt was also discussed, including the role of wider fisheries policy (particularly spatially-specific licensing) in affecting opportunities for diversification. Connections between fisheries, the wider 'working waterfront' and tourism were discussed, as well as issues around safety, identity and social cohesion. The cause-effect mapping exercise highlighted how the implications of changes in fishing behaviour are context-dependent. In the cultural theme, for example, the severity of knock-on effects for coastal communities would depend on factors such as the type of fishing (the "metier") and the reliance of the community and wider industries on the fishery, as well as the social and economic wellbeing or, conversely vulnerability, of individual fishing communities.

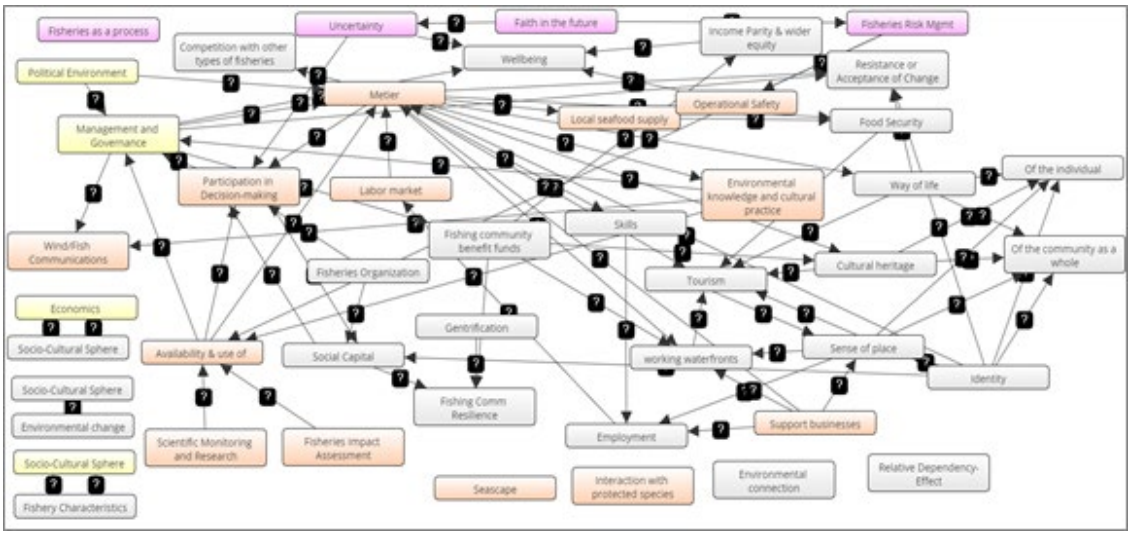

Figure 5. Cause effect maps describing interrelationships between changes in fishing behaviour, OWF development, and cultural impacts.

In order to illustrate how the generic cause-effect maps might be used to evaluate a specific situation, the second cultural theme break-out group began to work through two particular examples. The first was the experience of a partnership between Ørsted and crab/lobster fishers in Bridlington, UK, which showed how the pursuit of best practices in impact assessment led to positive outcomes in a number of areas including social capital, research capability and capacity, and the provision of new infrastructure, which attracts tourism (Figure 6). The second example (Figure 7) related to the concerns about possible socio-cultural effects from potential displacement of the surfclam fishery in the US. This fishery has only a limited ability to diversify due to specialised equipment and the centralised location of processing facilities. Many of the boats are owned by the processors, creating the risk of losing a whole sector if a business is no longer profitable. Losing fleets will likely affect the support businesses including cold storage providers, with implications for other fishing fleets.

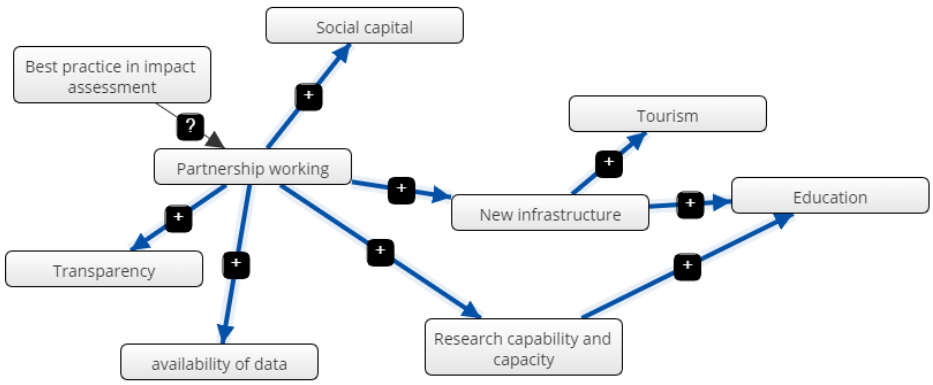

Figure 6. Cause effect map on cultural benefits from partnership working between Ørsted and crab/lobster fishers in Bridlington, UK.

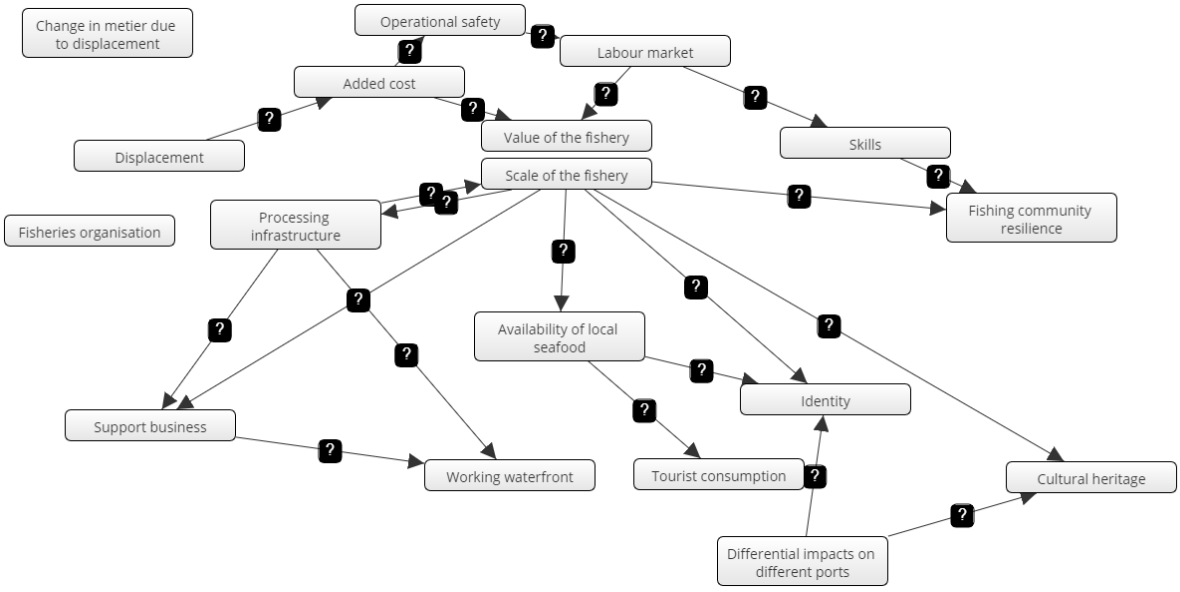

Figure 7. Cause effect map on concerns about possible socio-cultural effects from potential displacement of the surfclam fishery in the US.

5 Plenary sessions on cross-cutting themes

The plenary sessions were used for feedback and full-group discussions. This included discussing similarities and differences between the European and US contexts, evidence and data gaps, as well as the need for a better understanding of cumulative socio-economic impacts.

5.1 Identified common issues and differences between European and US regions

A focused plenary session compared and contrasted the European and US contexts. The facilitator presented a summary of some key issues that had been raised as part of the break-out sessions. These were identified in the presentation as:

System-wide characteristics

- Fisheries have deep-rooted (often centuries old) histories that define communities;
- Global & regional & local market forces have complex relationships to fisheries;
- Offshore wind is a new ocean use (U.S.)/newer use (Europe/U.K.);
- Societal demand for offshore wind energy is rapidly increasing;
- Fixed and floating wind technologies are rapidly changing;
- Fisheries are transboundary- spatially and temporally dynamic by nature, while wind development is fixed by location; and, thus, stationary systems are being imposed on those that are not stationary and not-managed as such (the ecological, bio-physical, and fisheries governance and human economy).

Similarities identified across regions and impact categories

- Lack of an integrated appropriately-scaled and commonly-defined fisheries assessment framework;
- Scientific uncertainty associated with survey/assessment displacement and understanding fisheries ecological effects/impacts especially beyond the turbine scale;
- "Graying" of fishing fleets/new entrants (i.e. increasing average age of fishermen);
- Power imbalances in decision-making and communication processes Examples of when collaborative science/ventures have had some positive inter-industry outcomes;
- Fisheries adaptations to wind are dependent on many factors including policies, technologies, capital, and cultural/social/demographic characteristics;
- Displacement may occur by policy, operational constraints, or both;
- Challenges associated with insurance; these were stated to vary by degree and detail across countries (and in U.S. are still speculative);
- Need for regional data collection (or spatially relevant data collection); for example, flatfish in the southern North Sea have different life history stages within different countries' waters and highly migratory species in U.S. will need assessment across full migratory route beyond state waters;
- Value of fisheries knowledge & expertise.

Differences identified across regions and impact categories

- Offshore wind policy/governance structures (e.g., planning, permits, compensatory mitigation);
- Fisheries policy/governance structures;
- Fisheries-dependent data collections;

- Factors outside of wind (e.g., spatial conflicts with vessel traffic in Antwerp, Rotterdam, Hamburg);
- Major oceanographic features such as hydrographic boundaries and bathymetry (e.g., Mid-Atlantic cold pool);
- Geographic boundaries and bathymetry, and whether fixed foundations or floating (e.g., US east vs. west coast);
- Differences in fisheries spatio-temporal management;
- Foreign vessel competition.

During the session, participants discussed the issues raised and were also given the opportunity to provide additional input on the respective regional situations through an anonymous menti-meter poll. Additional input from participants was received for the following two open-ended questions and is listed verbatim below (edited only for typographical errors):

1. *Are we missing any key similarities between US and Europe (recognizing there are differences within Europe and differences within the US)?*

- Motivation of fishers to be engaged in finding solutions [to conflict]
- Pace of development
- Lack of respect for fishers data and knowledge
- Available marine space
- Scale of development
- Scientifically we do not properly understand fishing behaviour, making it difficult to make predictions
- Extent of Marine Protected Areas?
- There are differences within Europe that are important to recognize. [This exercise is a simplification that may not be useful]
- Power imbalances between fishers and new users such as wind development
- Shifting baselines
- Concerns about assessment of cumulative effects and impacts
- Difference in structure of the fisheries supply chain (vertical vs horizontal integration)
- Difficulties in opportunities for fishers to engage in process, e.g., fishing is not a 9-5 job and the issue of having a voice in a large process vs being able to be part of the process to achieve outcomes
- Both US and Europe have robust sets of baseline fisheries data
- Public perceptions of wind energy and fisheries (likely this is a difference)
- Governance (ed. note: likely this is a difference)
- Similar types of fisheries and their importance to fishing communities
- Climate change and social interest to address mitigation
- Increasing fishing costs, e.g., regulatory and otherwise, outside of offshore wind challenges
- Perceptions of inevitability of having to share space
- Gear conflict
- Uncertainty of how and when OWF will expand
- Need for fishing outreach requirements
- Local negative impacts on fisheries vs regional positive impacts to energy planning
- Benefits of offshore wind development to coastal communities, e.g., port redevelopment

2. *Are we missing any key differences between US and Europe?*

- Level of uncertainty among US fishermen is very high and may be attributed to the lack of experience of OWFD of any significant scale
- Liability differences associated with cable protection, e.g., wilful damages vs. resulting from culpable negligence and fact U.S. is not a signatory to UNCLOS
- Marine space, extent and nature of MPAs
- Litigation risk in U.S. is higher
- Scale and cultural significance of fisheries is greater in U.S. legal systems (ed. note: may depend on specific state, country, etc.), fisheries management, and types & vulnerabilities of fisheries, e.g., shellfisheries in U.S.; and level of fisheries organization (perceived to be higher in U.S.)
- Public perception of the importance or value of fisheries, recreational fisheries importance, and cultural cohesion of public perception in Europe
- Coastal community differences, e.g., population densities in coastal zone
- Climate change mitigation policies
- Scale of development, U.S. wind will be far from shore and much larger installations than how wind development emerged in Europe
- Maturity of industry and experience of industry over time
- Public engagement process is more extensive in U.S.
- Lack of other offshore energy co-uses in U.S. Atlantic such as oil and gas in North Sea (but similarity in the U.S. Gulf of Mexico)
- Greater protected species management issues in U.S.
- Minimum energy density requirements (MW/Km2) that apply in Europe may not apply to U.S.
- Potential impacts from invasive species colonizations (but this may also be a concern in U.S.)
- Europe array grids are not 1 by 1 nm layouts
- There are large differences within European countries as well (e.g., UK) Rochdale Envelope Case Law, e.g. applications define worst case scenarios at planning stage in UK but this means that key issues like cable and layout are post consent.
- Perception that fishers in Europe may be more open to co-existence than those in U.S., depending on jurisdiction, and maybe more willing to negotiate on mitigation /compensation.

5.2 Evidence and data gaps

As time limitations prevented detailed discussion on the issues of evidence and data gaps, a further menti-meter survey was used to allow participants' input on this topic. For each issue participants wished to raise, they were asked to answer four connected questions:

1. What information do we need to understand better the socio-economic implications of offshore wind/fisheries interactions?
2. Why?
3. Is this information already collected? By whom?
4. What are the needs/challenges associated with obtaining this information?

Thirty-nine responses were received during the workshop, which covered topics including: identifying thresholds for positive and negative impacts; the acceptability and feasibility of co-location; fishers' responses to displacement (and improved understanding of their behaviour more generally); the socio-economic drivers behind compensation; and the level of community dependence on fisheries. The need to document the baseline situation was also highlighted. This survey remained open after the workshop, as did a related set of questions in which participants were asked to identify the key 'pinch points' for which evidence was required for each of the three themes. These 'pinch points' were those key factors in the cause-effect relationships on which other effects were particularly dependent. There were a total of 84 entries for the environmental theme 'pinch points' during the workshop, with the most common being distribution (N=15), abundance (N=9), loss of fishing grounds (N=6) and fishing behavior change (N=6). Out of 80 entries for the Economic theme 'pinch points', displacement (N=16), access to fishing grounds (N=9), and business risk/uncertainty (N=8) were the most frequent entries. For the cultural theme 'pinch points,' participation in decision making (N=9), metier (N=8), management and governance (N=7) and fishing community resilience (N=7) were the most frequent responses out of 72 entries.

5.3 How to assess the cumulative impact from OWFs on the fishing sector and fishing communities?

One of the most important tasks for the future will be to address the cumulative impacts of OWF development, researching and understanding biological, physical, and geological changes linked to OWF infrastructure, and the economic, social and cultural implications of changes in fishing activity with the wider interactions between fishing, coastal communities and society.

One OWF may not have large negative impacts, but multiple wind farms together, along with associated cabling infrastructure, collectively may have severe negative impacts (Berkenhagen *et al.* 2010). Therefore, an assessment of cumulative effects, taking all existing and proposed OWF globally into account, is essential in the future (Stelzenmüller *et al.* 2020).

Another effect to consider would be the cumulative pressure those wind farms have together with other human activities, especially where direct and indirect effects (positive/negative) on the marine environment are common across different uses (Gimpel, 2015). Such pressures can even be strengthened by external factors such as climate change or the COVID-19 pandemic (see Figures III, VII and X in Annex 4).

As the analysis of cumulative effects would have gone beyond the scope of the workshop, we foresee a strong link to other ICES working groups such as the Working Group on Cumulative Effects Assessments in Management (WGCEAM), which will work towards a common framework for cumulative effect assessment in order to evaluate the spatio-temporal scale of such effects in different ecosystem regions.

6 Conclusion and Recommendations - Developing best practices in managing fisheries & OWF interactions

WKSEIOWFC demonstrated the importance of improving our understanding of the socio-economic implications of OWF and fisheries interactions. The event was attended by participants from nine countries who represented policy/regulation, the fishing and OWF industries, consultants and academia.

The workshop allowed us to describe, summarise and illustrate perceptions of the various potential environmental, economic and cultural effects that offshore wind development may have on fisheries. Moreover, we were able to highlight the complexity and interconnectedness of the issues under discussion.

We further explored common issues between European and US regions such as complex interactions of new OWF technologies in combination with traditional fisheries that are strongly linked to the identity of coastal communities. Similarities identified across regions such as lacking integrated, appropriately-scaled and commonly-defined fisheries assessment frameworks, as well as the scientific uncertainty associated with surveys beyond the turbine scale, helped us to define issues that need to be addressed in the future. In addition, key differences were identified between European and US regions, noting that intra-regional differences exist within European jurisdictions and within US regions. Notable key differences include the policy and governance structures both for offshore wind permitting and for fisheries management; fisheries in Europe have a longer history of interacting with installed wind projects than fisheries in the US and this may contribute to greater perceived uncertainty in US; further, the scale and cultural significance of fisheries in general is much greater in some geographic regions than in others.

Evidence and data gaps were mostly related to identifying thresholds for positive and negative impacts, the acceptability and feasibility of co-location and the fishers' responses to displacement. The latter is particularly important as the fishers' behaviour can be driven by social factors such as working rhythm (Schadeberg *et al.* 2021), which need to be understood in order to assess the real impact of OWF development on fisheries.

An expanded, future effort should further explore the three-dimensionality of effects we describe in our conceptual representation of the interactions between environmental, economic and social/cultural changes, and how these different elements were partitioned into the three main workshop themes (Fig. 1). Further, it needs to address the effect of multiple OWF, the effects of OWF in combination with other human and external drivers of change (while likely not an exhaustive list, some examples provided during the workshop included shipping and transport, climate change, or the COVID-19 pandemic).

In conclusion, more research is needed to assess potential impacts of the development of OWF on the fishing sector, fishing communities and economic activities onshore. The results of this workshop will be carried further as the WGOWDF addresses its ToR A. This will include the following efforts: further analyse, review and summarise the results of mental models, identify linkages between different model dimensions, evaluate and identify metrics for measuring important factors and conditions for each of the sub-models, and identify and prioritise where there are data gaps requiring new research. This understanding can be used to foster information ex-

changes, collaboratively address science questions, and support decision-making. These activities are considered to have a very high priority on a global level, especially as offshore wind energy expands.

Here, we foresee a strong link to other ICES working groups focussing on topics related to our WKSEIOWFC:

- Working group on Marine Benthal and Renewable Energy Developments (WGMBRED), that works on the assessment of benthic effects of offshore wind farms;
- Working Group on Economics (WGECON), that works among others on economic indicators and the challenge of bringing fisheries economics into ICES science and advice;
- Working Group Marine Planning and Coastal Zone Management (WGMPCZM), that works among others on the assessment of conflicts, the potential of coexistence and synergies;
- Working Group on Maritime Systems (WGMARS), that works among others on bringing together social and natural scientists to inform integrated ecosystem assessment;
- Working Group on Social Indicators (WGSOCIAL), that works among others on the development of cultural indicators, the definition of fishing communities in ICES regions and the social and cultural significance of commercial fishing;
- Working Group on Cumulative Effects Assessments in Management (WGCEAM), that works on the development of a common framework for cumulative assessments to be applied in the context of ecosystem-based management.

7 Acknowledgements

We would like to thank all the WKSEIOWFC participants who gave input during the Workshop and contributed to this report.

8 References

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Annex 2: Workshop resolution

A **Workshop on the Socio-economic implications of offshore wind on Fishing Communities (WKSEIOWFC)**, initiated by the Working Group on Offshore Wind Development and Fisheries (WGOWDF), and chaired by Tara Hooper, UK; and Annie Hawkins, USA, will hold an online meeting, 15–17 March 2021 to:

a) Define the impact from offshore wind development for fishing behaviour, fishing communities and coastal economies;

b) Review and report on fishing industry interactions with offshore wind development and document lessons learnt including effects on the distribution of fishing operations (Science Plan codes: 2.2; 2.3; 2.7)

WKSEIOWFC will report by 1 May 2021 for the attention of SCICOM.

Supporting information

Priority	The activities of this workshop will lead ICES into issues related to the socio-economic effects of offshore wind farms on fisheries. In regard to the rapid expansion of the wind energy sector, these activities are considered to have a very high priority.
Scientific justification	Term of Reference a) Europe has been operating offshore wind energy facilities for 20 years. North America is on the verge of large-scale development. The European experience can be used to document the effects of offshore development on fishery operations, fishing communities, and fishery economics. Existing knowledge on the impact of wind energy on fisheries is focused mainly on ecological impacts, there is a clear knowledge gap on the economic and socio-cultural impact of the expansion on the fishing behaviour, fishing communities and coastal economies While there are distinct differences in the scale and scope of fisheries between the North American and European wind development areas; there is also the opportunity to identify common issues and promote research to address these issues. Defining and describing the effects and impacts from offshore wind development on fisheries and fishing communities will ultimately support to understand the fishing industry interactions with offshore wind development.
Resource requirements	No specific resource requirement beyond the need for members to prepare for and participate in the meeting, this will provide the main input to this worksho
Participants	The workshop is expected to attract 25-30 WGOWDF members and guests from the field of fisheries economics, social science, fisheries, wind energy development, licencing/permitting authorities and other relevant stakeholders.
Secretariat facilities	Standard support.
Financial	No financial implications.
Linkages to advisory committees	There are no obvious direct linkages, but developing the expertise could link to ACOM in the future.
Linkages to other committees or groups	There is a very close working relationship with the WGMPCZM, WGECON, WGSOCIAL, WGMRE, WGMBRED, WGSEDA and WGMARS.
Linkages to other organizations	There are linkages to fishing organizations and wind developers in the USA and similar linkages in Europe, including wider links to licencing/permitting authorities and other relevant stakeholders.

Annex 3: Presentations from other ICES Working Groups

- *Marloes Kraan* from the Working Group on Social Indicators (WGSOCIAL) about the Development of cultural indicators, the definition of fishing communities in ICES regions and the social & cultural significance of commercial fishing.
- *Arina Motova & Eunice Pinn* from the Working Group on Economics (WGECON) about Regulatory Requirements for Wind Farms and Socio-Economic Impact Assessments in the Up, economic data and future challenges (incl. indirect effects on the wider fishing community).
- *Arina Motova* from Working Group on Economics (WGECON) about the work of this expert group and the challenge of bringing fisheries economics into ICES science and advice.
- *Patricia Clay* from the Working Group on Maritime Systems (WGMARS) about the multidimensionality of the term "Stakeholder" and about bringing together social and natural scientists to inform integrated ecosystem assessments.
- *Andrew B. Gill* from the Working Group on Marine Benthal and Renewable Energy Developments (WGMBRED) about the 'Cause-Effect' relationship analysis developed in WGMBRED to assess benthic effects of offshore wind farms.
- *Kira Gee & Andrea Morf* from the Working Group for Marine Planning and Coastal Zone Management (WGMPCZM) about Conflicts, coexistence and synergies in MSP and how to assess them.

Annex 4: Results from the pre-workshop survey

Environmental

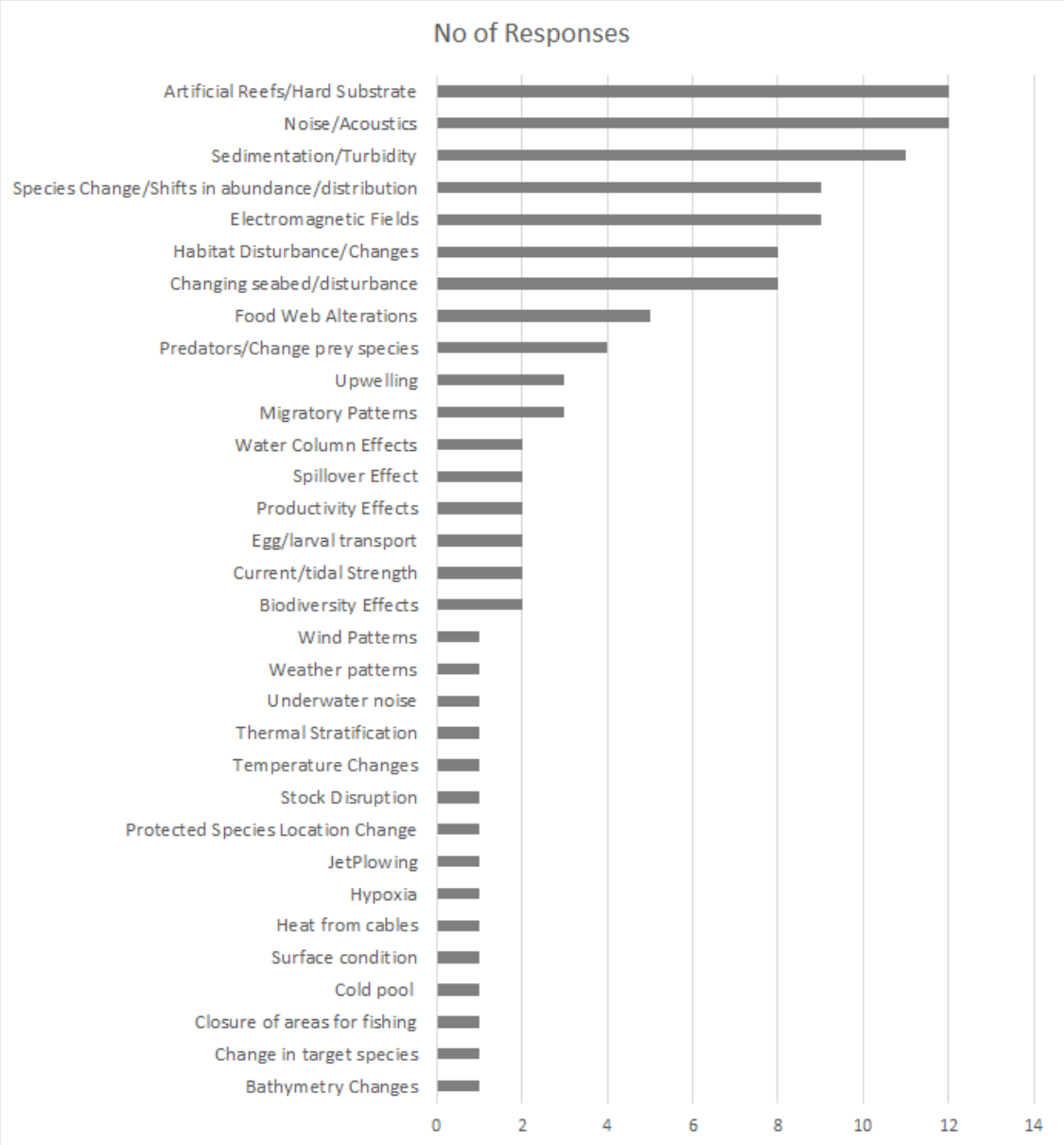

Figure I. The number of responses for each theme identified within responses to the question "What are the environmental changes associated with offshore wind farms that could affect individual fishing behavior?"

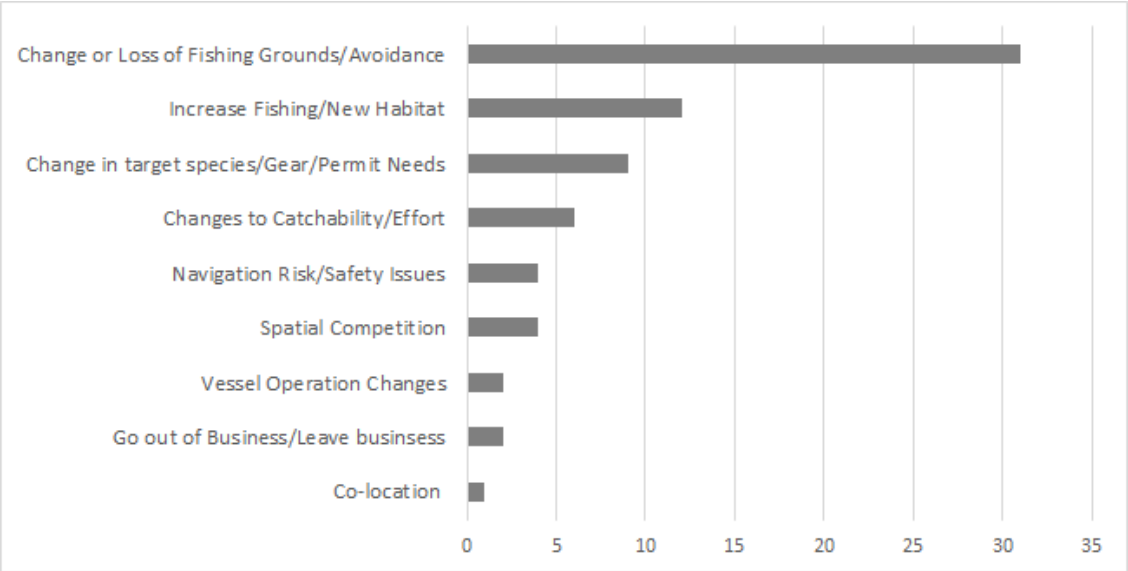

Figure II. The number of responses for each theme identified within responses to the question "What are the environmental changes associated with offshore wind farms that could affect individual fishing behavior?"

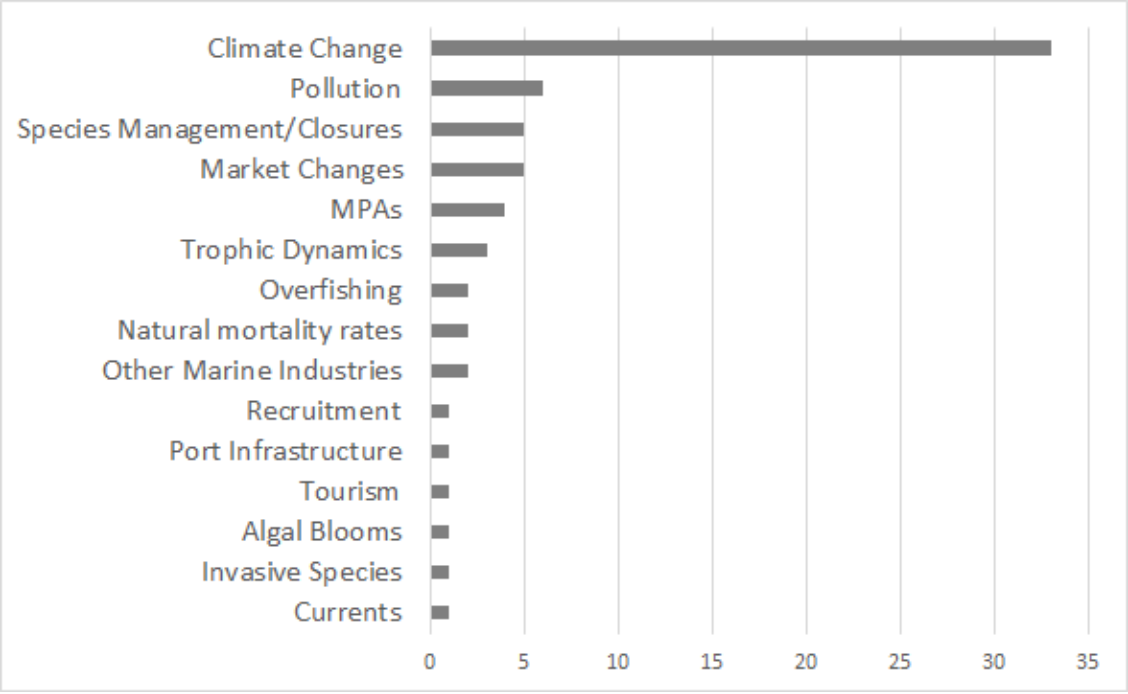

Figure III. The number of responses for each theme identified within responses to the question "What other environmental factors, not connected to OWF development, might lead to fisheries changes?"

Economic

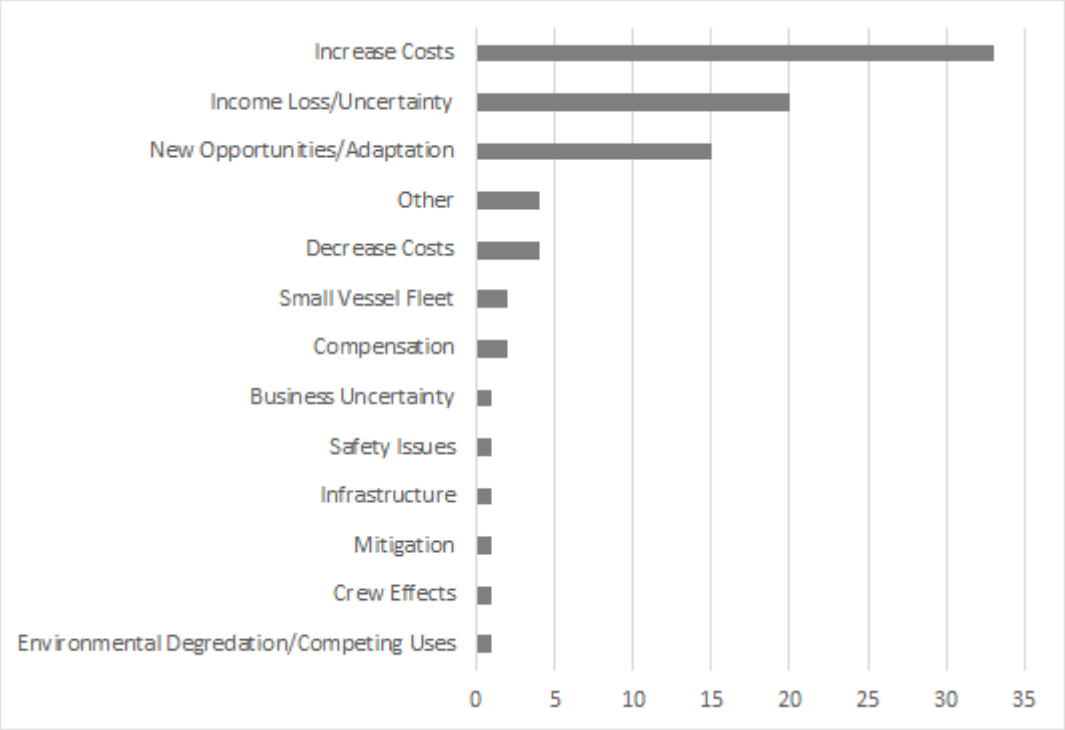

Figure IV. The number of responses in each of the main themes identified within responses to the question "How could the costs and income generation opportunities for individual boats change in response to OWF development?"

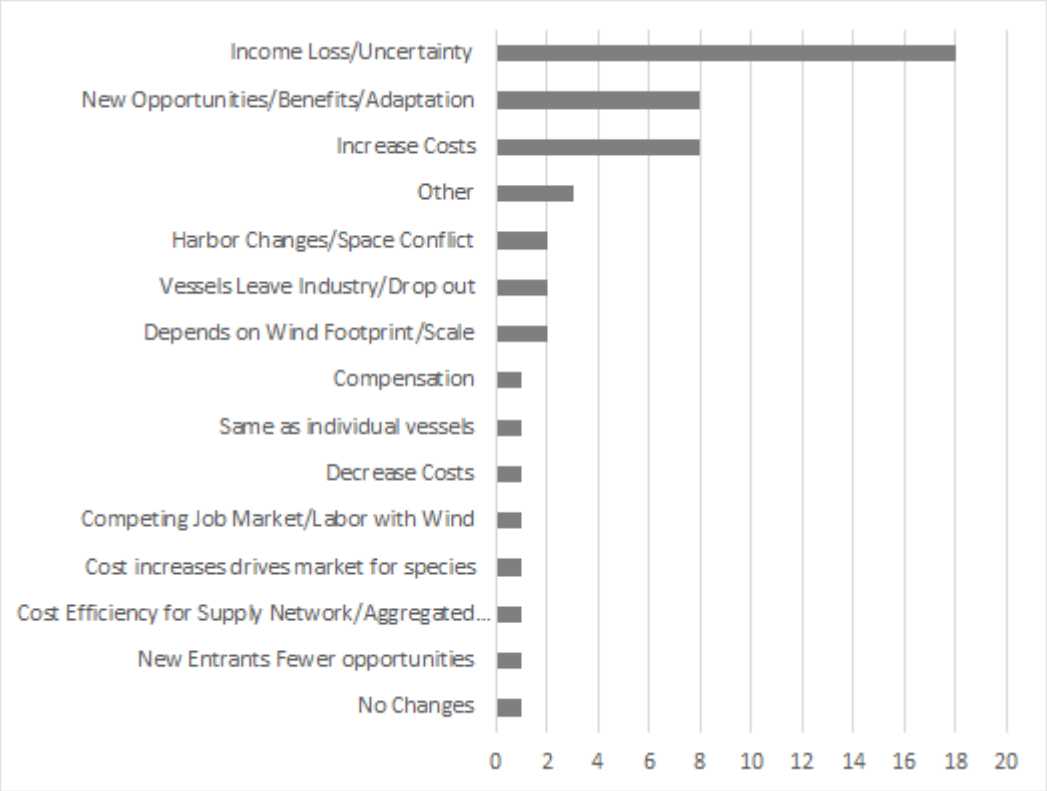

Figure V. The number of responses in each of the main themes identified within responses to the question "What changes in costs/income generation opportunities could occur at the scale of the fishing sector?"

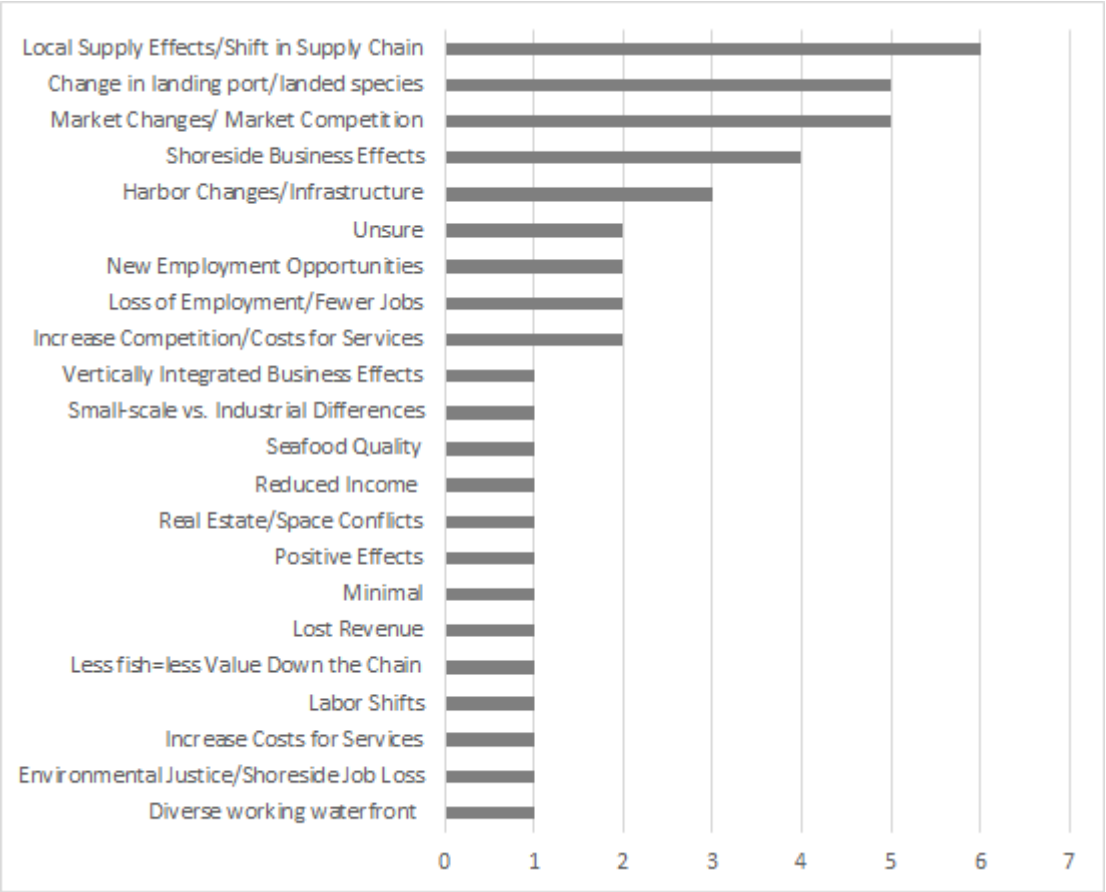

Figure VI. The number of responses in each of the main themes identified within responses to the question "What are the potential economic consequences for the wider value chain onshore?"

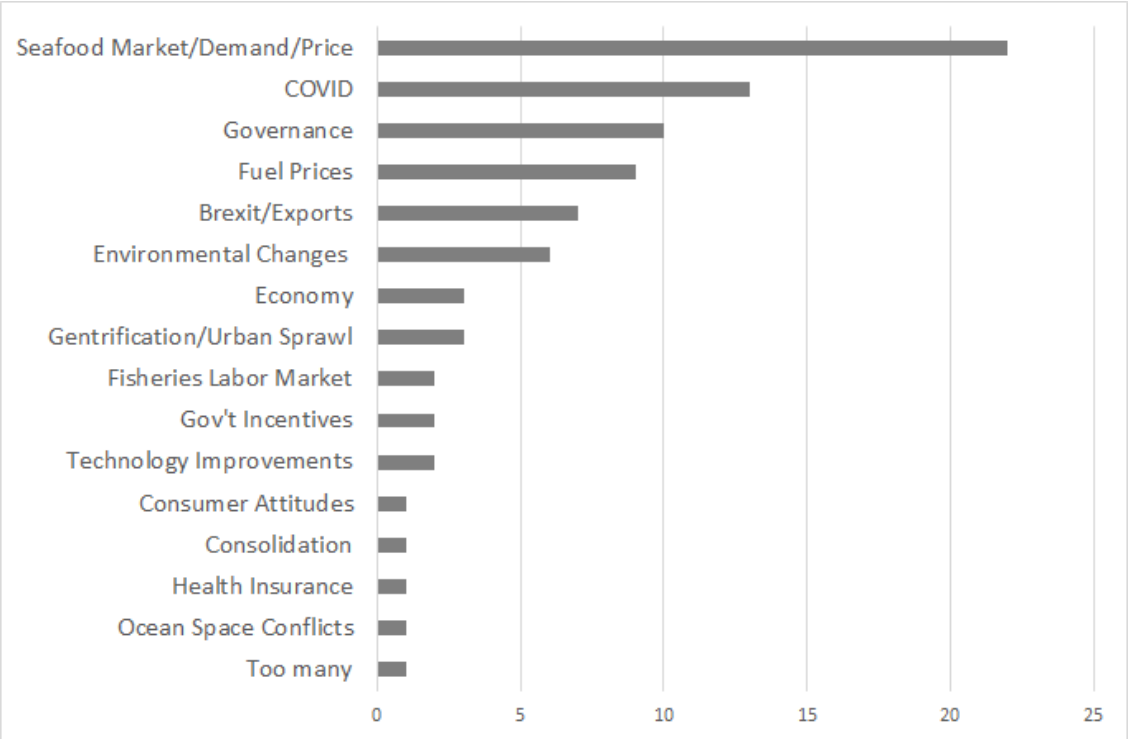

Figure VII. The number of responses in each of the main themes identified within responses to the question "What other economic changes, not connected to OWF development, are impacting fisheries?"

Cultural

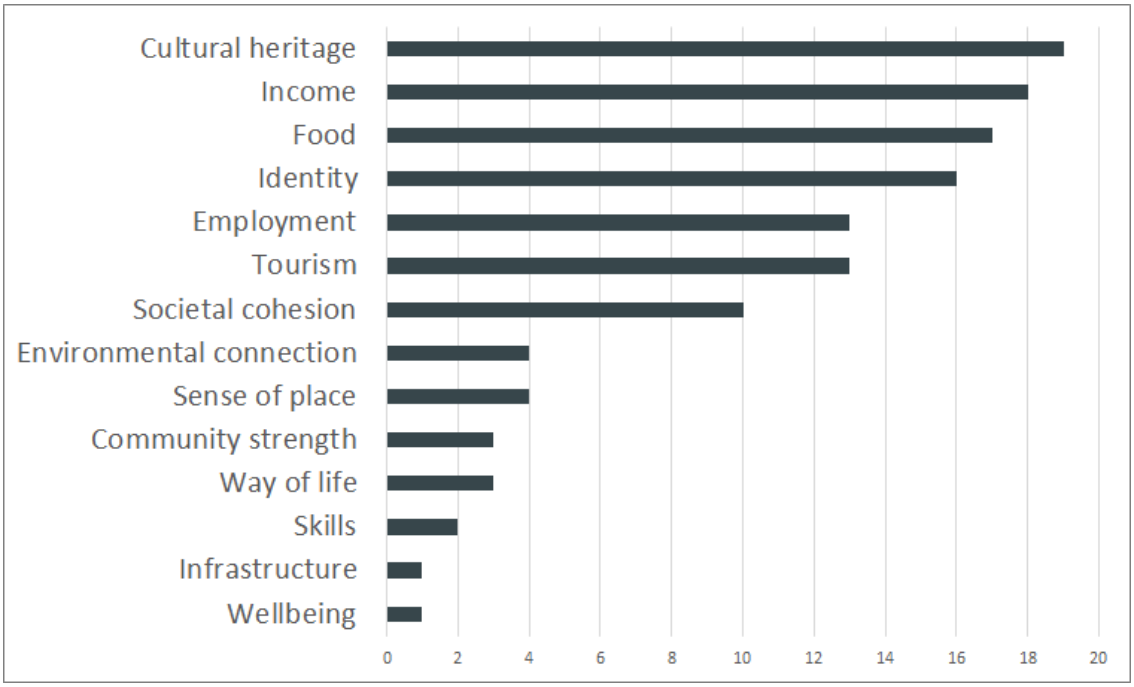

Figure VIII. The number of responses in each of the main themes identified within responses to the question "In what ways is fishing important to coastal communities and wider society?"

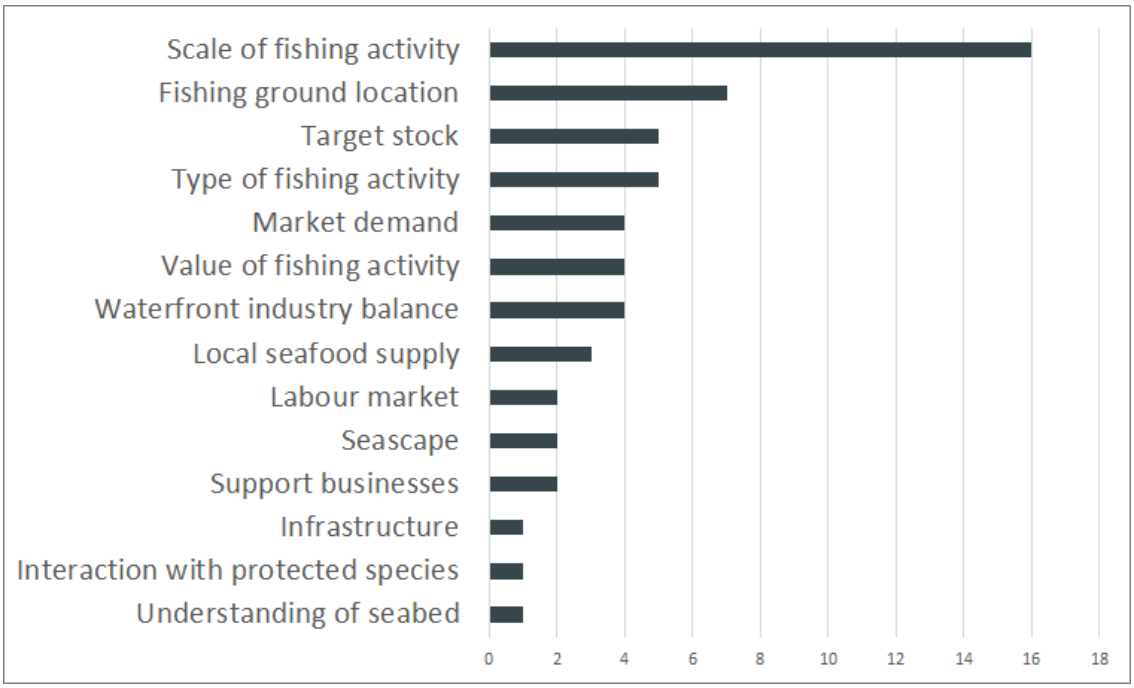

Figure IX. The number of responses in each of the main themes identified within responses to the question "What types of changes in fisheries would affect those interactions with coastal communities and wider society?"

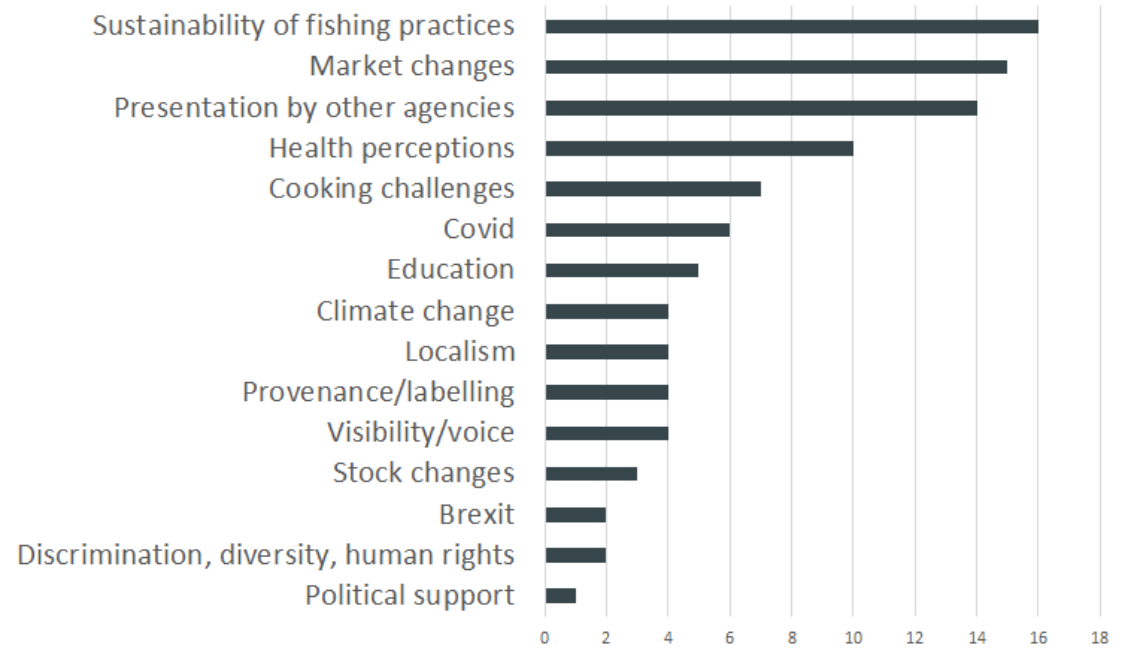

Figure X. The number of responses in each of the main themes identified within responses to the question "Apart from OWF development, what else might be affecting seafood consumption and public perception of fisheries?"