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Original Article

Putting fishing communities on the map in ICES ecoregions

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Abstract

This paper highlights the importance of identifying fishing communities for fisheries and ecosystem-based management, which often focuses on fleets and ecological impacts rather than on the communities where fishers live and land their catches. Fishing communities are key to understanding the broader impacts and benefits of fishing, as they support many livelihoods in fleet and trade-related activities. Recognizing these communities, allows for better data collection, analysis, and informed policy-making. ICES WGSOCIAL developed a method to identify fishing communities across ICES ecoregions, first applied in the Celtic Seas and North Sea ecosystem overviews. These overviews describe ecosystems, identify human pressures, and assess their impact. Using fishing ports as proxies, our method links socio-economic indicators (e.g. landings value) to communities. We identify limitations to our methods and explore the complexities of defining a 'fishing community' due to its dynamic, multidimensional nature. We discuss next steps for improving our mapping approach and deepening our understanding of the social, cultural, and economic value of fishing, and why these matter for applied marine science in support of policy and management.

Keywords: fishing communities; ecosystem overviews; ecosystem-based management; fisheries management; marine social-ecological systems; social data

Introduction

Ecosystem-based management (EBM) represents a holistic method of managing marine resources. It recognizes the intricate interdependencies within marine ecosystems, including the relationships between different species, their habitats, and human activities. In fisheries, EBM emerged in response to the realization that the traditional focus on obtaining maximum yields for single species was insufficient to prevent the depletion of fish stocks (Pikitch et al. 2004). By considering the cumulative impacts of fishing along with environmental and socio-economic factors, it seeks to achieve sustainable fisheries while maintaining the resilience and biodiversity of marine ecosystems. The principles of EBM are enshrined in fisheries and marine resource policies around the globe (FAO 2012, Rudd et al. 2018). The International Council for the Exploration of the Sea (ICES), which offers science-based advice to its twenty member nations, has adopted EBM as a guiding principle (Wilson 2009, ICES 2023b).

To provide the evidence base for EBM, ICES introduced the ecosystem overviews (EOs, e.g. Barents Sea EO (ICES 2009). The content of these EOs was reviewed for the first time in a dedicated workshop in 2013 (ICES 2013). Since then, the EOs have been developed further through a series of workshops involving stakeholders, including clients/advice requesters (i.e. governments, regional sea conventions, regional fisheries organizations, etc.), the fishing industry, non-governmental organizations, and scientists [see the ICES Stakeholder Engagement Strategy for a typology of different stakeholders and

their roles in the science and advisory process (ICES 2023d)]. The EOs provide a broad ecosystem context for other ICES advice products, such as fishing opportunities, special requests, and fisheries overviews. They are considered key advice products underpinning the ICES EBM approach, and provide the ecosystem-informed science and advice needed to meet the current and future needs of clients and stakeholders (ICES 2022a, 2023c, Roux and Pedreschi 2024). However, whilst ICES recognizes EBM as the primary way of managing human activities affecting marine ecosystems, until recently the EOs *only* focused on impacts caused *by* humans. The impacts of ecosystem or management changes *on* humans and their communities have historically been neglected.

ICES began to focus on the human dimension aspects of fisheries and marine management with the creation of the Strategic Initiative on the Human Dimension in 2015. The Working Groups on Social Indicators (WGSOCIAL) and Economic Indicators (WGECON) were established in 2018 to provide methodologies, tools, and approaches to integrate human dimensions into ICES science and advice (ICES 2018a, 2018b). In addition, a dedicated workshop on how to include human dimensions in integrated ecosystem advice was held (ICES 2020b). The mapping of fishing communities in the EOs, initiated by WGSOCIAL in 2020 and carried out with WGECON members, is a key activity of this work.

This paper outlines the process of identifying and mapping fishing communities, with a focus on commercial fisheries, as a critical first step in including social information in the EOs. Fishing communities are an important, yet often neglected unit of observation and analysis for fisheries advice and management, which typically focuses on fleets or on métiers [fishing activities, initially introduced by Biseau and Gondeaux (1988)] as a combination of gear, target species, season and fishing area, and since further elaborated in the European Union (EU) Data Collection Framework (EC 2016, p. 51 Table 2, p 55 Table 5B). However, the majority of fishers, whether working on or owning vessels, belong to fishing families and land their catches in locations that sustain multiple livelihoods through fleet and fish trade-related activities, as well as ancillary services such as tourism. Fishing communities are the anchors of both activities, on land as well as at sea (St. Martin and Olson 2017, Charles 2023), and often reflect the social and cultural importance of fishing, resulting in wellbeing, identity-formation, knowledge and (im)material cultural heritage (Ounanian et al. 2021, Basurto et al. 2023). To understand the full impact of fishing, it is essential to consider these fishing communities beyond just the 'fleet' level. Following a short introduction of fishing communities as a concept, we describe the stepwise process that was taken to 'put fishing communities on the map' in the EO for the Celtic Seas ecoregion, followed by the Greater North Sea ecoregion. Our process demonstrates that mapping fishing communities is not a straightforward task, because 'a fishing community' has multidimensional characteristics, is dynamic, and its definition is context-dependent. The method presented uses landing ports as a proxy for fishing communities. This choice has limitations, which we will outline, as well as proposing next steps. Finally, we will discuss ways to better understand the social, cultural, and economic value of commercial fishing, and why these matter for applied marine and fisheries research in support of policy and management.

What is a fishing community?

Fishing communities serve as vital units of observation and analysis for studying the socio-economic impacts of fishing, including their contributions to well-being, identity, cultural heritage, values, and knowledge. These communities form a crucial link between the natural ecosystem, where fishing occurs, and the social system which humans inhabit, enhancing our understanding of the human dimension of fisheries and their social-ecological interplay. This link has typically been overlooked by management (Jentoft 2000, Lam 2021). Defining a fishing community is, however, a challenge; one that has been discussed in various previous studies (Jentoft 1996, Symes 2000b, McGoodwin 2001, Brookfield et al. 2005, St.Martin et al. 2007, Clay and Olson 2008, St. Martin and Hall-Arber 2008, Urquhart et al. 2011, Donkersloot and Menzies 2015, Ross 2015, St. Martin and Olson 2017, Zador et al. 2017, ICES 2021b, Charles 2023). The concept of fishing or, more broadly, coastal communities also appears in fisheries policies in ICES member countries and from clients, including the European Union (EP and CEC 2013), Norway (Holm and Henriksen 2016, Regjeringen 2024), the United Kingdom (UK 2022), the United States (NOAA 2007), and Canada (Daly et al. 2020). However, the degree to which these fishing or broader coastal communities are defined varies significantly, with some countries providing well-developed and detailed definitions (US, EU), while others adopt broader or less specific interpretations (Norway, United Kingdom, Canada). In the literature, definitions of fishing communities centre around three overlapping perspectives: (i) place-based; (ii) social and cultural-historic, and (iii) practice-based. Table 1 provides an overview of these three perspectives. Other perspectives, such as 'communities-at-sea' (St. Martin and Olson 2017) and 'community of interest' or 'community of the mind' (Ross 2015) are embedded in these three main definitions.

A clear-cut, universal definition of a fishing community is elusive. The three main categorizations of fishing communities (Table 1) underscore that boundaries between them are blurred. For instance, the practice-based community approach focuses on identity as shaped by a way of life and shared worldviews, rather than being strictly tied to a geographical place, whether on land or at sea, along with their associated socio-ecological and cultural-historic dimensions. Furthermore, when conceptualizing fishing communities, it is critical to acknowledge heterogeneity, for instance, by considering the notion of 'community members.' A review study (Hamelin et al. 2024) found that two primary categories of members can be distinguished: (i) those who have a role in the fishing industry, and (ii) those residing in a place-based fishing community. These categories of community members are not always distinct, as individuals like fishers can be positioned in both groups (*ibid.*). Both types of community members can influence or be influenced by fishing and its associated activities. Additionally, we note that broad terms such as 'fishing community' and 'fishing industry' carry complexities related to the role and positioning of Indigenous people, rightsholders and stakeholders, as well as those involved in subsistence, commercial (small and large scale) and recreational fisheries and aquaculture (Song and Soliman 2019, Delgado-Ramírez et al. 2022, Hamelin et al. 2024).

Developing a comprehensive definition of fishing communities requires thorough qualitative research. Given the

Table 1. Three (overlapping) perspectives of fishing communities.

Community perspective	Fishing community defined by:	Sources
Place-based	Geographical spaces that connect sea-based activities, such as fishing, with land-based activities like trading, consuming, living, etc., fostering a sense of belonging and attachment to a specific coastal place and fishing practices.	(St. Martin and Hall-Arber 2008, Urquhart et al. 2011, St. Martin and Olson 2017, Charles 2023, Kraan et al. 2023, Symes 2023)
Social and cultural-historic	Connection to place and landscape, where harvesting and processing practices influence economic structures, labour roles, kinship, and social organization, shaping individual identities. Even when fishing ceases to be a central economic activity, its historical and cultural significance often endures. As such, these communities depend on the fishing industry for their economic, social, and cultural vitality.	(Symes 2000a, McGoodwin 2001, Brookfield et al. 2005, Britton and Coulthard 2013, Urquhart and Acott 2013, Vriend 2020, Duggan et al. 2023, Kraan et al. 2023)
Practice-based*	Shared practices—such as target species, fishing gear, or processing methods on land—and the adaptive behaviours and knowledge these foster, which build identity, resilience, and social cohesion.	(Ross 2015, Pauwelussen 2016, St.Martin & Olson 2017, Zador et al. 2017, Pardie & Campion 2022, Cramer et al. 2023)

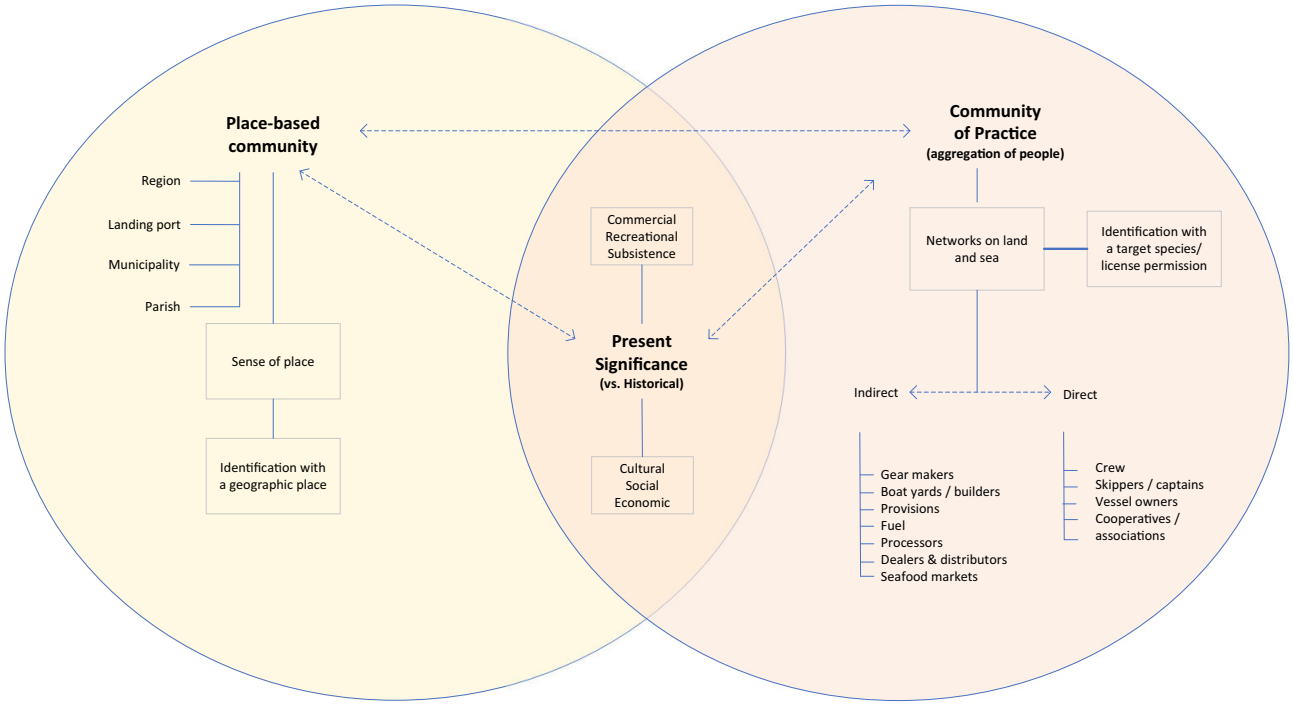

Figure 1. Conceptual model of the social and cultural landscape of fishing communities. Definitions in Table 1. Source: ICES 2021.

inherent complexities in defining fishing communities, the process of 'putting fishing communities on the map in the ICES EOs' required us to make specific methodological choices, which we will elaborate on in the next section.

Methods

Step 1: Defining a conceptual model for fishing communities

The process of defining a fishing community began with a brainstorming session at the first annual WGSOCIAL meeting (ICES 2018a, 2021b). This was done by listing relevant attributes of fishing communities along with key social science research questions that could guide the assessment of the social and cultural significance of commercial fishing. This initial brainstorm resulted in a conceptual model of the landscape of fishing communities (see Fig. 1). This conceptual model aided us in developing methodologies that can help advance a common approach for defining fishing communities in the ICES regions. While acknowledging that aquaculture and recreational fisheries are often part of fishing communities (but can also be separate), we decided to focus on fishing communities with commercial fisheries. The main reason was a pragmatic one: we expected that for most ICES countries, data on commercial fisheries were available in a consistent way across countries, which is less often the case for aquaculture and

recreational fisheries. Our reasoning was that, once a working format for putting fishing communities on the map had been developed, this could be expanded to include aquaculture and recreational fisheries. As it turned, out focusing on commercial fisheries alone was already challenging enough.

This, together with the perspectives on what constitutes a fishing community in the literature (see the previous section), revealed that a fishing community is a multi-layered concept. The place-based, social and cultural-historical, and practice-based perspectives (Table 1) overlap, illustrating the complexity and depth of what defines a fishing community. Traditional definitions, which only link local fleets to local grounds and local markets, miss this complexity, as highlighted by (Symes 2000b). Instead, our conceptual model of the social and cultural landscape of fishing communities (Fig. 1) captures the more nuanced social and cultural landscape of fishing communities as 'an intricate and complex pattern of functional relationships between different local places, which are articulated through economic, social, administrative and political actions and through the interactions between different sectors of the regional economy' (Symes 2000b, p. 215).

Step 2. Application of mapping fishing communities in the ICES context

After discussing the different aspects of a fishing community, we explored potential applications. The Community Social Vulnerability Indicators Tool in the US by NOAA Fisheries (Jepson and Colburn 2013, NOAA Fisheries n.d.) served as a guiding example. With this online mapping and graphing tool, the well-being of over 4600 US coastal communities can be explored, assessed, and compared across 14 indicators, including commercial and recreational fishing engagement and reliance, and climate change related impacts (NOAA Fisheries n.d.). We note that under the current US administration (as of February 2025), certain original indicators as developed by Jepson and Colburn (2013) have been reconsidered. Consequently, the Fishing Communities Profiles website (NOAA n.d.) and the Fishing Community Social Vulnerability Indicators website (NOAA n.d.), which initially included all 14 original indicators, has been taken offline following the first review of this paper and its resubmission (March 2025). Reports on US fishing communities profiles, using original criteria are still available (Agar and Stoffle 2007, Himes-Cornell et al. 2013, Grace-McCaskey 2015, Michael Jepson et al. 2018, Norman et al. 2022, Michaelis 2024).

The US example strengthened our conclusions from the discussions that identifying the 'places' where land and sea activities occur and impact the marine ecosystem is a crucial first step, in understanding and assessing the roles of different people involved in making a livelihood. Fishing harbours exemplify such places: they are geographic locations that can serve as proxies for fishing communities, hubs of activity both on land and at sea, and points where we can link additional data and indicators.

We soon realized that the ICES EOs contained maps entitled *Catchment area for the specific ecoregion, showing major cities, ports, and ICES areas*. These maps showed the ecoregion with the sea being central, showing the countries bordering the sea with a number of different ports. However, the port information depicted on these catchment area maps appeared inconsistent across different EOs. For example, the Icelandic Waters Ecoregion map (ICES 2020a) showed 27 ports around Iceland alone (Fig. 2), whereas the Greater North Sea Ecoregion (ICES 2016) showed in total 43 ports for Norway, Sweden, Denmark, Germany, the Netherlands, Belgium, France, and UK (Fig. 3). The data used for the catchment area maps was derived from Environmental Systems Research Institute on global shipping lanes and harbours (ESRI n.d.).

Given that 'Fishing' is the top pressure listed in all of the regional EOs and that fisheries science and advice is core to the work of ICES, it was incongruous that the ports plotted were based on shipping, rather than fisheries data. The fishing ports and the number of ports portrayed can be distinctly different from shipping-dependent ports, as is shown in Figs 4 and 5 for the Celtic Sea Ecoregion.

WGSOCIAL agreed that it was important to provide some indication as to the importance (i.e. dependency) of fishing to communities in each ecoregion in the EOs. As such, we began to develop a consistent method for ICES to portray fishing communities, which could then be proposed for inclusion in the EOs in line with the 'pipeline proposal' process (ICES 2023c). Adding landing ports as a proxy to fishing communities to the EOs serves multiple purposes. First, the connection to society would be clearly represented, with landing ports serving as an initial step in defining and illustrating fishing communities in the EOs. Second, landing ports are geographical locations which can also serve as anchor points for other fisheries- related social and economic data (e.g. employment, landings values, economic dependency; see Fig. 5). Third, mapping landing ports is a valuable exercise for understanding the challenges of establishing a common EU-wide definition and methodology applicable to fishing communities, whilst taking local context into account. Lastly, the fishing community maps improve the socio-economic information within the EOs relevant to a key sector and its associated pressures, by helping to illustrate the societal benefits rather than just the ecological impacts of fishing (in line with EBM principles), and providing information relevant to other ICES advisory products, such as the ICES Fisheries Overviews (ICES 2022c).

Step 3. Determining the data source for mapping fishing communities

The next step was to determine how to obtain data consistently across all ICES regions. WGSOCIAL members evaluated several potential data sources to improve the EO maps. These included the 'Coastal Community' maps from the EU Fisheries and Aquaculture Socio-Economics group of the Joint Research Centre (JRC) and data collected under the EU Data Collection Framework (DCF) legislation (Natale et al. 2013). The EU fleet register was also assessed, but while this worked well in countries such as the Netherlands, where vessels are registered per community, this would not be suitable for Portugal. This is because some ports have registered boats and no registered fishers, even though they likely reside in the (commercial) fishing community where those ports are situated. Ports of registration would also not work, as in some countries there are only a few such ports of registration, which represent administrative locations where vessels are registered. However, the actual ports where fishing vessels operate can be much more numerous (e.g. Ireland in Table 2), and these would more accurately represent the fishing communities. We also found that the JRC data either underestimated or overestimated the number of ports reported nationally for many

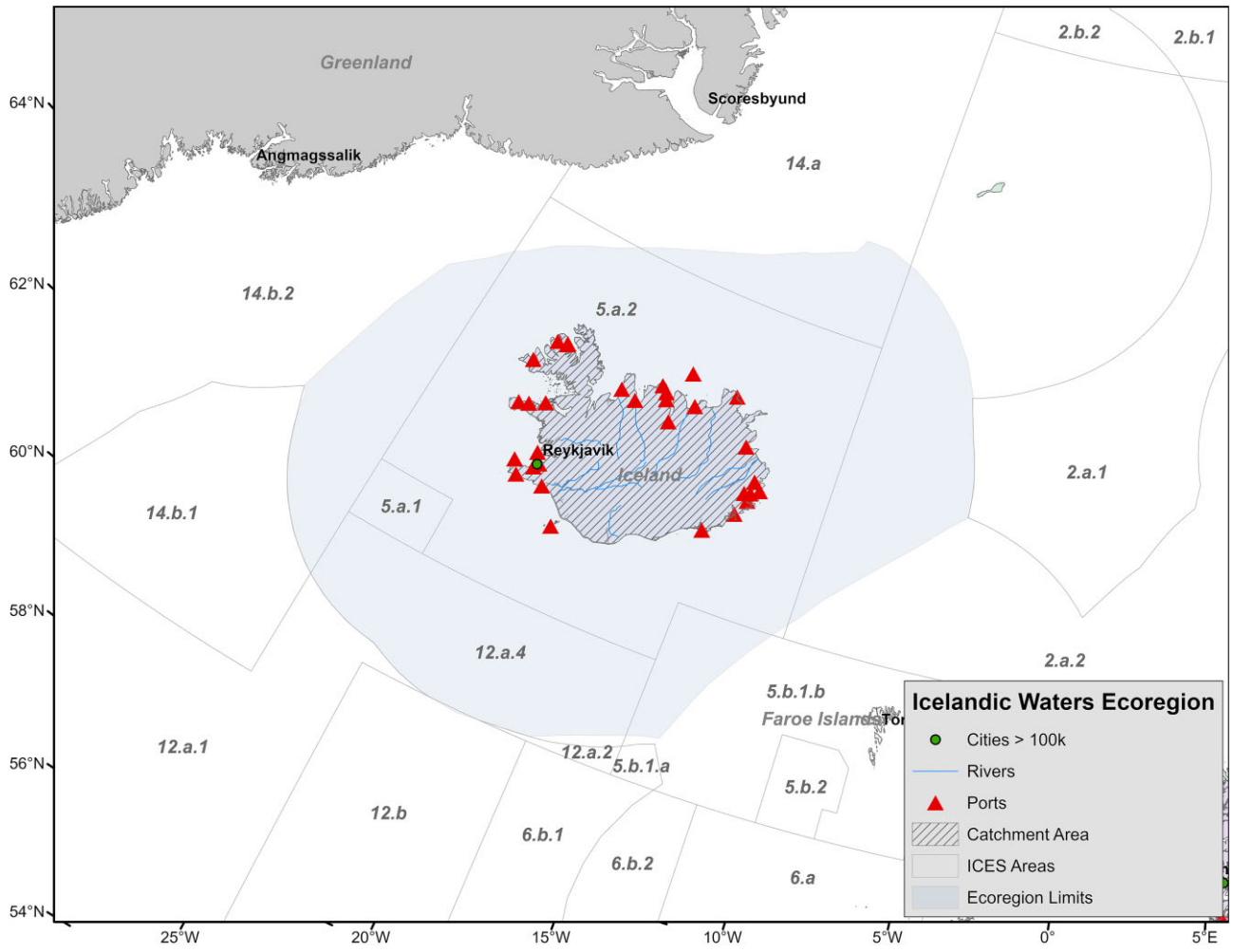

Figure 2. Map of ports in Icelandic Waters Ecoregion (ICES 2020a).

countries (Table 2) The landings and effort data published by the European Commission's Scientific, Technical and Economic Committee for Fisheries (STECF) are not reported by port, but aggregated by species, FAO Area level 3–4, and DCF Fleet segments. Given this, the JRC had to link the ports reported in the fleet register to the Annual Economic Report data by disaggregating the data to these new aggregations (Natale et al. 2013). However, port definitions differed at the EU member state level in the register. Furthermore, while average employment per vessel can be calculated from the data, it cannot easily be related to specific activities as employment is not necessarily proportional to effort. To conclude, despite our best efforts, no suitable, reliable, and accurate data source was found.

Given these constraints, WGSOCIAL decided to work with landing ports, with the data obtained from the ICES Regional DataBase (RDB) and Fishframe (as of 2023 replaced by the Regional Database & Estimation System or RDBES) (ICES n.d.). The database included information about fishing area and landing ports, enabling analyses linking spatial marine activity to onshore activities. This also facilitates insight into the inter-ecoregional dependence of fishing. The database covers all EU countries and the UK and can be used for other non-EU ICES countries (e.g. Norway). The approach uses ports of landing to disaggregate economic activities to countries and regions (as currently only done by some countries). Landing ports can be used as a proxy to attach economic and social indicators collected by EU DCF to terrestrial regions (aggregating as required). We note that while most of the biological information in RDB is mandatory, the home port and many vessel characteristics are optional (ICES 2018c).

Step 4. Pipeline process

WGSOCIAL decided to develop a proof of concept using the Celtic Seas EO as a pilot study, collaborating with the ICES Working Group on Ecosystem Assessment of Western European Shelf Seas (WGEAWESS) and WGECON. The pilot study was chosen based on available resources (opportunity) and strategic criteria, specifically the potential to incorporate its outcomes into existing advisory products.

To propose an addition to the EOs, WGSOCIAL had to develop a so-called 'pipeline proposal.' This is part of the 'pipeline process' that governs the incorporation of new topics into the EOs. The purpose of the pipeline process is to provide a space in which the ICES community can propose topics for inclusion in the advice. As such it aims to encourage growth, evolution and ensure ICES advice is based on the best available science and evidence. The pipeline process provides a 'testing ground' for developing new topics, with

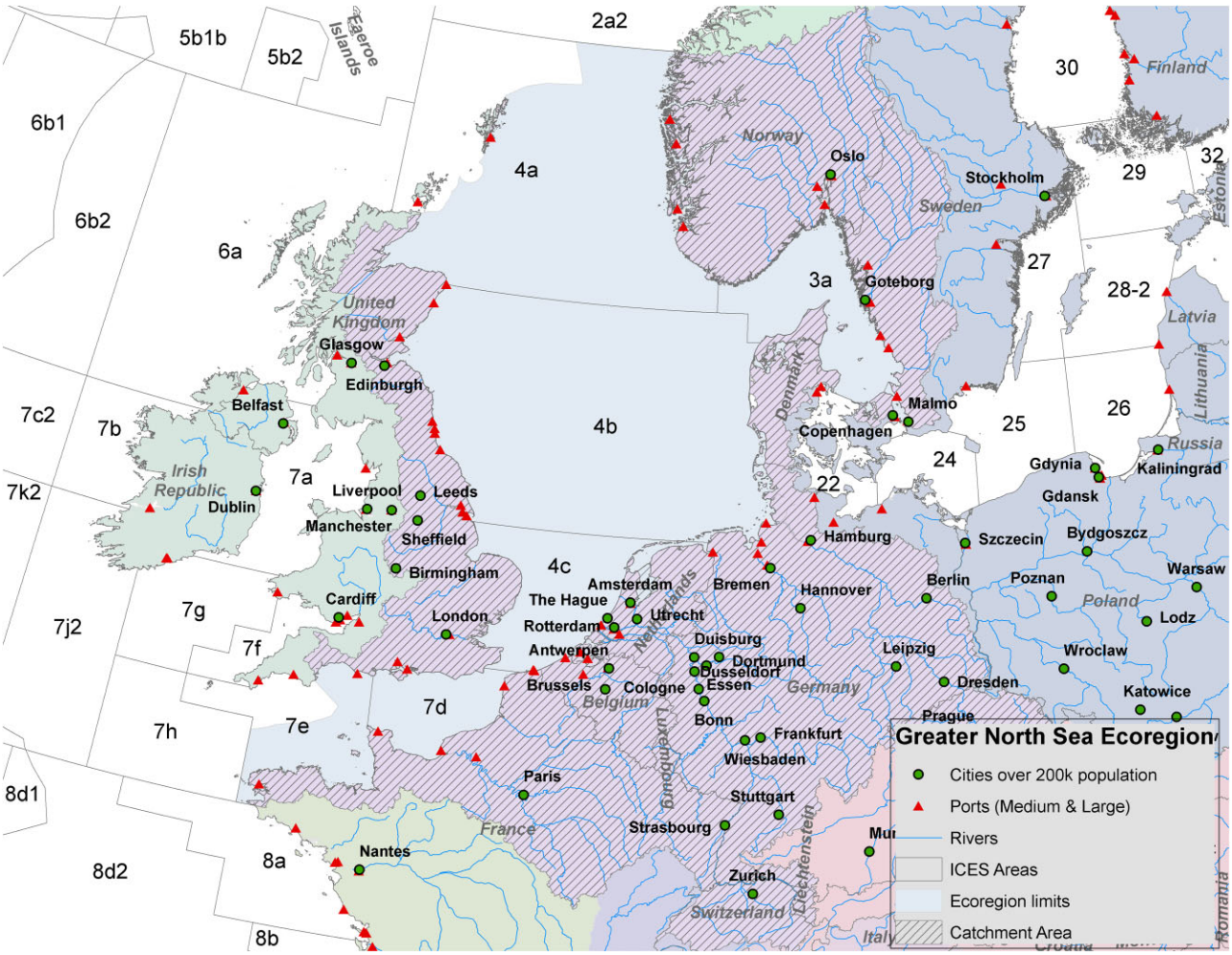

Figure 3. Map of ports in Greater North Sea Ecoregion (ICES 2016).

proposals/groups receiving review, feedback and guidance from the ICES Advisory Committee (ACOM). The ICES Technical Guidelines for the EOs outlines the process, and the criteria that a new proposal should meet for consideration (ICES 2023c). As part of this process, WGECON determined that the following data would be requested from the RDB for each ICES country: (I) landings (tonnes and value); (ii) landing country; (iii) landing harbour; (iv) vessel flag country; (v) year; (vi) species; (vii) vessel length category; (viii) area; and (ix) statistical rectangle (where no confidentiality issues exist).

For the Celtic Sea EO map, only the tonnage of the landings was used to assign the main port of landings to each vessel and to disaggregate economic indicators to specific regions. Later, when developing the North Sea EO maps, the value of landings was added, using the methodology developed for the Seafish fleet enquiry tool (Quintana et al. 2020, Seafish n.d.). Despite challenges such as the diversification of operations, landings at multiple ports by some vessels, market dynamics, vessel-level estimation requirements, and sample size limitations, this approach appeared to be the most practical. It allowed for a more comprehensive analysis of fishing communities at the regional level by incorporating a broader range of economic and social indicators. Aggregation issues were addressed, and since annual values are requested, data protection concerns were expected to be minimal.

Step 5. Producing maps for the EOs

The first EO featuring the new fishing communities maps using landing ports as proxies was published for the Celtic Sea in 2021 (ICES 2021a). The new maps were well received within the ICES community and among ICES clients. It was therefore decided that, dependent on resources, the fishing community maps would be developed for all EOs when scheduled for updates. The subsequent EO for the Greater North Sea was published later in 2022 using the same methodology, with the addition of a fourth indicator: the value of landings (ICES 2022b). This economic information was absent in the Celtic EO. Additionally, the Greater North Sea EO also incorporated catch-at-sea data.

The EO maps now display fisheries hotspots for each indicator. Given the rapid development of other activities claiming large areas in the North Sea, identifying the hotspots for fisheries is an important step to understand fisheries attachment to areas and in the future looking at community dependency of sub areas in the ecosystem.

Results

The Celtic Sea EO (ICES 2021a) was the first to feature fishing community maps using landing ports as proxy for fishing communities (Fig. 5). In addition to highlighting the fishing

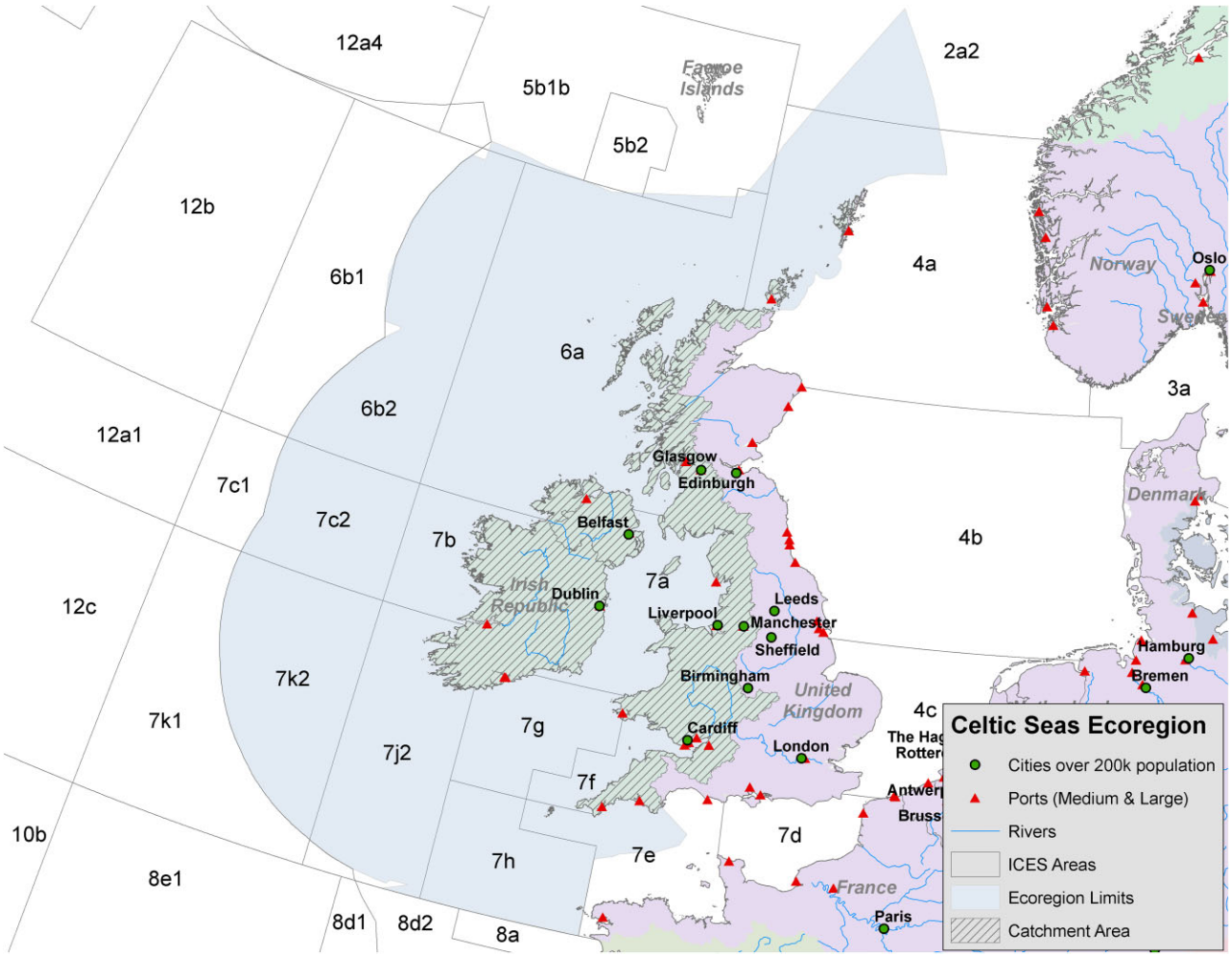

Figure 4. Map of medium and large ports in the Celtic Sea ecoregion in 2016 (ICES 2021b).

communities, relevant indicators (such as days at sea, landings by weight, and vessel length category) could be linked to the fishing communities to provide an initial understanding of the societal impact of fishing and its significance to the community. The results reveal that many communities on land can be linked to fishing at sea, and along with illustrating sizeable variability in landing weights and days at sea. A dramatic difference was observed in comparison to the original 'ports' maps in the EOs (Fig. 4), for instance by showing numerous ports in Ireland instead of only three (Figs 4 and 5). The maps also demonstrate that the Celtic Sea is vital not only to the fishing communities along its borders but also to those in other ecoregions, such as the Netherlands (IJmuiden) and Denmark (Skagen), due to the shared nature of EU waters. This illustrates how social-economic interdependencies can be rooted in complex historical connections, and strongly influenced by policy.

For the Greater North Sea EO (ICES 2022b), new maps that also included economic information were produced (Fig. 6). While fishing intensity revealed few hotspots (i.e. in the Channel and the Kattegat), the data indicates that fishing activity, when considering all fleets over a 3-year period, is fairly evenly distributed across the entire North Sea. However, certain areas can be identified as more productive (highest landed volumes) or lucrative (highest value). Given the rapid development of other activities competing for large areas in the North Sea, identifying fisheries hotspots is crucial for understanding fisheries attachment to areas and, in the future, assessing potential displacement scenarios and trade-offs, along with community dependency within sub-areas of this ecosystem.

Discussion

The new maps in the EOs have put fishing communities on the map in the ICES context, particularly in the EU. This can be seen as a first step towards making fishing communities visible and highlighting the human dimensions of fisheries within ICES through the development of additional social, economic, and cultural indicators to complement an ecosystem approach to fisheries management. Fishing communities serve as the anchor point where activities at sea materialize on land, and provide an additional unit of observation to which new indicators can be connected to further demonstrate the value of fisheries for society. Once such data is presented, analysis can be done to show differences among countries, fleets, métiers, or communities. It can also show differences in time, for instance show trends of change to assess the likely impact of a given policy proposal.

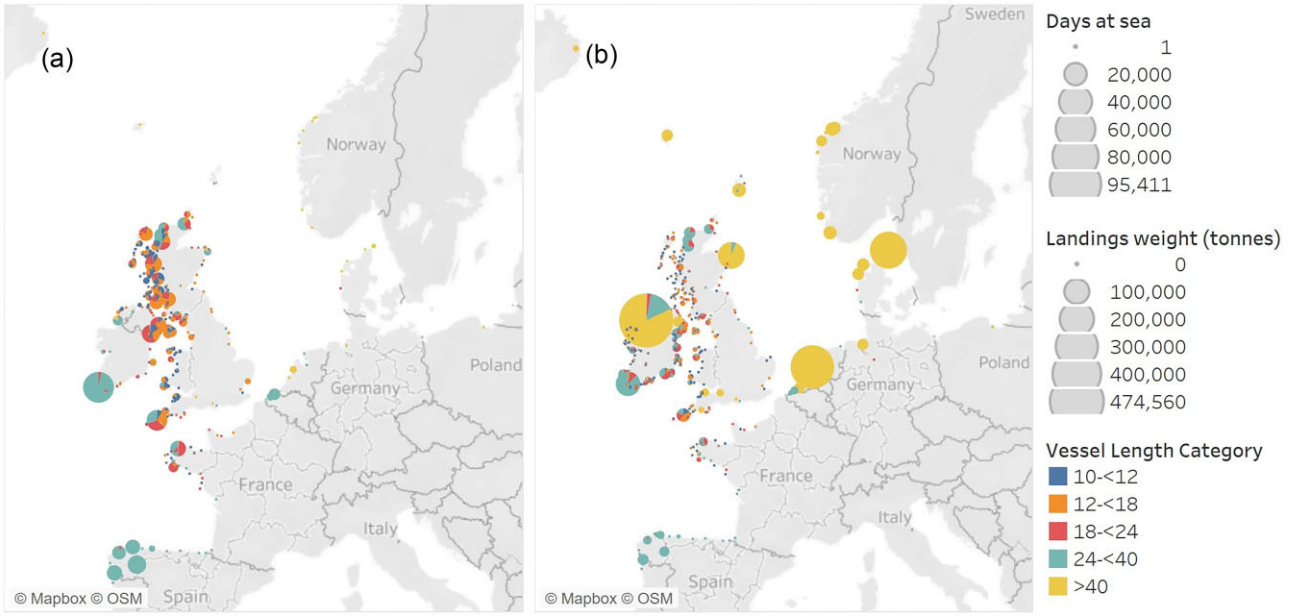

Figure 5. Fishing effort (days-at-sea; panel a, left) and landings by weight (panel b, right) for each port with vessels operating in the Celtic Seas ecoregion (2017–2019). The size of the circles indicates magnitude, colours indicate the vessel length category. Small scale fisheries (vessels <10 m) are not included as vessels of this size are not required to have VMS, and not all countries consistently collect catch and landings data for small scale fisheries. Note: days-at-sea were estimated for Ireland based on hours fished (ICES 2021a).

Table 2. Comparison of the number of ports in the JRC database and other sources (e.g. EU Fleet Register, national institutes) by Member State (country).

Country	Number of ports JRC database	Number of ports correction	Additional DB(s) used
The Netherlands	34	50	EU Fleet Register, *Gids van vissersvaartuigen* (Guide for fishing vessels) Rijksdienst voor Ondernemend Nederland
UK	123 places of registration	Over 560 ports/landing sites	EU Fleet Register, Marine Management Organization landings by port data sets.
France	35	593 but includes '*outre mer*'	EU Fleet Register, IFREMER
Portugal	26	166 (46 aggregated)	EU Fleet Register, Directorate-General for Natural Resources, Safety and Maritime Services
Germany	150	135	EU Fleet Register, DCF/EUMAP
Slovenia	3	3	EU Fleet Register
Italy	267	44	EU Fleet Register, MHI, World Port Index, VMS, WIKI
Sweden	362	207	Vessel register database from the *Sveriges Officiella Statistik* or (Swedish Agency for Official Statistics).
Norway		750	Norwegian Coastal Administration
Spain (Galicia)	69	69	Pescadegalicia
Ireland	11	45	EU Fleet Register, Marine Atlas

For the purpose of the EOs, using landing ports as a proxy for fishing communities gives a pragmatic implementation to highlight social, economic, and cultural factors of fisheries. The data allows for detailed analysis of benefits and impacts of fishing per port, e.g. landings weight and value per species and fleet, which can be a valuable insight for policy makers. The regional sea perspective highlights that not only do bordering countries have a stake, but fleets from more distant countries are also involved. Lastly, by adding certain variables, such as fishing activity at sea, new insights can be gained such as fishing hotspots per harbour.

While landing ports were chosen as proxy for the purpose of the EOs, other applications may emphasize other aspects of the concept fishing community. As this study has highlighted, the term 'fishing community' is a multi-faceted concept, thus the operationalization of the concept (e.g. community of practice rather than land-based community; see Table 1) may differ depending on the policy objective or the goal of the research project (with a different context or scale), as well as the data or skills available. For instance, in the Netherlands, a social impact assessment used the fleet registry to identify fishing communities rather than landing ports (Kraan et al. 2023). This choice was made because if landing ports had been used, the fishing community of Urk would not have shown up on the map. The Urk community is one of the main fishing communities in the Netherlands, with a large fleet, and the largest auction for flatfish in Europe. However, it does not have a landing port anymore, as it became land-locked due to enclosures in the 1930s and land reclamations after the second World War. While using landing ports as a proxy fits the purpose of the ICES EOs, there are limitations to this method, which we will discuss below, along with possible next steps.

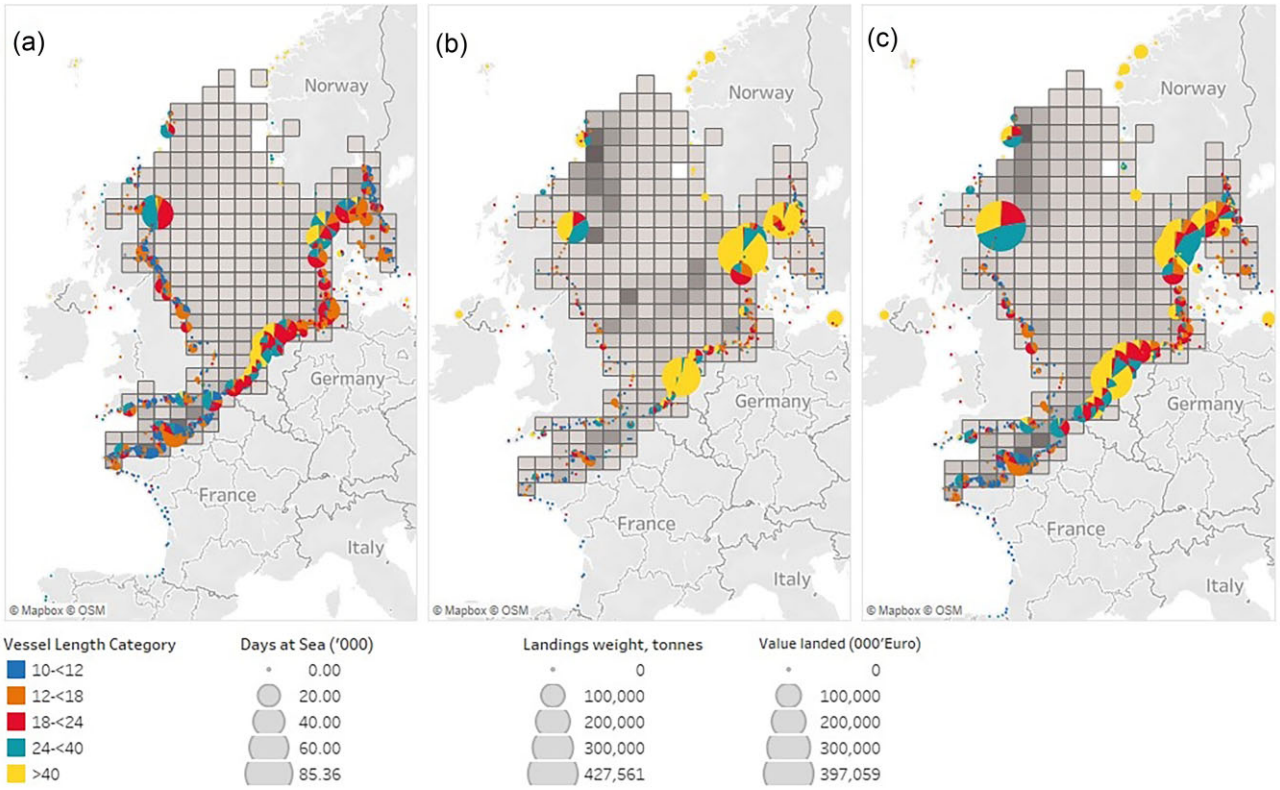

Figure 6. Fishing intensity (a), landings by weight (b), and value of landings (c) for each port with fishing vessels active in the Greater North Sea ecoregion (2017–2019). Size of circles represents order of magnitude, colour represents vessel length category. The grey colour gradient at sea indicates the fishing intensity per indicator per ICES rectangle. Vessels below 10 m are not included. Norwegian data missing (ICES 2022b).

Landing ports as proxy for fishing communities

Although landing ports serve as *proxies* for fishing communities, they fail to fully encapsulate the complex social, cultural, and economic dimensions that define these communities. Referring back to the conceptual model and based on our knowledge through the different case studies referred to in the study, the mapping of fishing communities in the EOs through landing ports corresponds with placed- and practice-based fishing communities, but not necessarily identity-based, which implies deeper social and cultural ties to fishing. Therefore, the data may imply inaccuracies when compared to actual practices, or the maps might fail to represent existing communities due to the data selection or aggregation. For instance, some fishing fleets, such as Belgian vessels in the Celtic Sea or Dutch vessels operating in Denmark and France, land their catch in one port but sell it in another fishing community, often a different country. While the social and economic impact appears to be centred around the landing port, in practice, it may be dispersed elsewhere. Consequently, it is crucial to realize that the landing ports identified through the data do not provide an understanding of *why* these fishing communities are on the map nor why certain fleets fish in another ecoregion. There are various reasons why fishers might choose to land in a particular port (e.g. availability of cold storage), which may not necessarily reflect the importance of that fishing community to the fishers. For the Belgian demersal fleet fishing in the Celtic Sea, the basis lies in historical rights. Another example can be found on the East Coast of England, where some fishing communities have struggled to maintain a competitive fish market as certain vessels have shifted their landing sites to the Brixham market in the Southwest with higher fish prices. However, this does not always involve landing directly in Brixham. Instead, they may land in Southwold, where Brixham-based agents provide cold storage. Although these vessels remain registered in ports like Wivenhoe and land their catch in Southwold, it is Brixham that likely reaps most of the social and economic benefits from these landings (Sinclair 2023). Similarly, in Portugal, some communities land in their home port but sell their catch at another fishing port where there is a first-sale point and/or better prices. Although these examples provide insights into the factors influencing the choice of landing port, further research is needed to explain such observations.

Current data from the RDB(ES), limitations of the maps and next steps

The data used for the production of the two EOs so far comes with certain caveats. First, data of non-EU countries is not always available in the RDB(ES) database. For instance Norwegian data is not yet available and thus could not be included in the Greater North Sea EO. Furthermore, while most of the biological information in the RDB(ES) is mandatory (ICES 2018c), the home port and numerous vessel characteristics, pertinent to mapping fishing communities, remain optional. To give an idea, for the North Sea data for 2017-2020 the landing harbour data was missing in 12% of the observations, corresponding to 6% of landings weight, 10% of landings value and 17% of seadays.

Second, EOs use data from logbooks to obtain landings, and from vessel monitoring systems (VMS) to assess fishing effort, which provides data on vessel location, course, and speed to fisheries control authorities at least every 2 h. However, in general, detailed logbooks (at the trip level and including the port of landings and fishing area) are not mandatory for vessels under 10 m in length, and VMS was not required for vessels under 12 m in length (CEC 2009). As a result, the small-scale European fleet isnot captured by our analysis for the EOs. This fleet represents about 8% of the landings of EU Member States and the UK across the greater North Sea and Celtic Sea ecoregions for the 2017–2019 period [based on the Annual Economic Report 2022 (STECF 2022)]. While 8% of landings in these ecoregions may appear minor at first glance, it is crucial to consider the number of smaller vessels responsible for these landings. These smaller vessels often play a significant role in fishing communities, and their contributions may actually tell a different story than one solely based on the percentage of landings.

A third caveat is that our approach also excludes other kinds of fishing, such as shellfish gathering on foot (without the use of a vessel), and recreational fishing, which is non-commercial and primarily done for leisure, with catches intended for personal consumption or sharing with family and friends. Marine recreational fisheries in Europe are estimated to contribute ∼10.5 billion euros, supporting around 99 500 full-time equivalent jobs (Hyder et al. 2020). In certain areas in the Mediterranean sea, this activity accounts for over 10% of total fishing production (Morales-Nin et al. 2005, Font et al. 2012, Lloret et al. 2018). Consequently, the geographical approach used by ICES in their EOs may not be suitable for regions with a large small-scale fisheries fleet, fisheries that do not use vessels, or recreational fishing, as it would leave a significant portion of the fishing community unaccounted for (e.g. Galician Waters, Western Iberia, the Gulf of Cádiz, and Western Mediterranean Sea). For small scale fisheries this caveat will be addressed with the implementation of the new fisheries Control Regulation (EP and CEC 2023), which mandates tracking systems for small-scale fisheries. The regulation recognizes that alternative technologies to satellite-tracking devices can be used to transmit vessel position data (see art. 9.3). However, exemptions apply to vessels of <9 m until 2029, emphasizing the need to combine other data sources to include small vessels in the accounting of fishing communities, given the important role of small-scale fisheries in Europe (Pascual-Fernández et al. 2020). Where feasible, advancements can also be made by utilizing locally available data. For instance, in Galicia (Spain), a monitoring system for small-scale fisheries was introduced for the period 2000–2018, with an average of 3000 hauls observed per year. Combining this with officially declared fishing days, an atlas by métier was produced (Molares et al. 2020). Similarly, the Basque Country (Spain) has spatial-resolution multidisciplinary data resulting from a collaborative participatory mapping programme (Murillas-Maza et al. 2023). These examples highlight the potential to mobilize local-level information to improve the definition and understanding of fishing communities.

A final data caveat is that the EOs illustrate the connections between fleets fishing in the ecoregion and landing their catches in the communities of that or a neighbouring ecoregion. However, some fleets operate even further away. For instance, the Spanish distant waters fleet includes vessels that fish in the jurisdictional waters of other non-EU countries in four continents (FAO 2011, 2022, García-Isarch et al. 2012). In the current analyses, the starting point was the activity at sea within the ecoregion (defined by where the fishing occurs). The link to the communities was based on where this fish was landed. A complementary approach could involve gathering all data related to a specific set of fishing ports (e.g. within an ecoregion) and linking it to all fishing grounds, regardless of the ecoregion, since some ports rely on fish caught in other regions.

All current EO maps have limitations associated with them. It is important to note that the data associated with fishing communities and fishing areas can exhibit temporal variation. Maps produced for 2017–2019 will show different results if aggregated at a seasonal level or for a different (or longer/shorter) time period. Making these maps available online and as interactive tools would enhance the use of the underlying data significantly. The current report format of the EOs (as PDFs) restricts this adaptability, also limiting the ability to zoom in on specific countries, communities, or fleets. If the maps were available as interactive online resources, users could zoom into particular areas to examine the importance of fishing for specific communities, similar to how the US Community Social Vulnerability Indicators Tool (offline as of March 2025) operated (NOAA Fisheries n.d.). This would provide a clearer understanding of community dependencies and communities of practice (at sea). In the current format, this level of detail is unattainable. Additionally, in the current format the data on the maps can partly overlap, making them less clear to interpretation.

Furthermore, the existing EO maps only show the current impacts of fishing. In the future, they could also be utilized to examine the impact of policy measures on coastal communities, similar to practices in the US (Clay and Olson 2008, St. Martin and Olson 2017) as well as the impacts of disaster-related events. Additionally, the maps could facilitate more straightforward cumulative impact assessments (or evaluations of carrying capacity) regarding the development of specific projects, following an ecosystem-based and precautionary approach. Moreover, these maps may assist in evaluating the resilience of communities and their capacity to respond to and adapt to external changes, and to consider an adequate spatial and community-based resolution.

Efforts to integrate the human dimension in fisheries advice should recognize the prevailing challenges in defining fishing communities and measuring the impacts of policy and environmental changes on fishing in these communities. Definitions set boundaries of what falls in and out of what a fishing community is, and this can have significant implications, particularly for policy design and impact assessment. The scientific community in the EU is collaborating through the STECF Expert Working Group on Social Data in Fisheries to develop an operational definition of fishing communities (STECF 2024). This definition understands communities as places not geographically narrowly bounded and uses fisheries to highlight the linked importance of fishing with ancillary activities and the value chain (*ibid.*). Here, it is important to recognize that in many countries, inland fisheries and aquaculture are significant sectors that are often interconnected with the marine fisheries sector. They share value chains and ancillary industries and can hold mixed social and cultural significance. Focusing solely on (marine) landing ports as proxies for fishing communities may overlook these important aspects. In

addition, this STECF working group is developing national fisheries profiles and fisheries community profiles (STECF 2024), following the example of the US where such profiles are already available (Agar and Stoffle 2007, Himes-Cornell et al. 2013, Grace-McCaskey 2015, Michael Jepson et al. 2018, Norman et al. 2022, Michaelis 2024). These profiles will assist EU policy-makers in contextualizing social and economic data and can be used for social impact assessments. The profiles can also be linked to future interactive online ICES EO maps of fishing communities, providing in-depth analyses that complement the information presented in the current EOs. Further steps, focusing on specific social and economic indicators at the community level and their connections to fishing hotspots at sea, could also be included in the ICES Fisheries Overviews, another advisory product. Integrating various tools and resources will foster a more comprehensive understanding of fishing communities.

Despite the current limitations, mapping fishing communities in EOs is a significant advancement. Although these communities are currently mapped using specific definitions and data sources, this initiative has sparked discussions about the impact of fishing and how to measure it. Criticisms and questions have emerged precisely because these communities are now being visualized. Additionally, the growing demand for more indicators to be included, suggests that the current maps are prompting new questions and deepening our understanding of the social dimension of fisheries. With fishing communities in the picture, also other (such as more qualitative) data sources or methods can be used to provide information from and about fishing communities to managers.

Conclusions

By putting fishing communities on the map, ICES has begun to bridge the gap between marine and social sciences, emphasizing the human dimensions that are often overlooked in traditional fisheries management. We described our methodology for mapping fishing communities in ICES EOs, showing that while landing ports can serve as proxies, they may not fully capture the social and economic complexities of these communities. Our analysis, based on a conceptual model, RDB(ES) data and case studies, indicates that landing ports may represent place-based communities but may not fully reflect the cultural and social ties that define them. Some fishers may belong to a community of practice that is not centred around the landing port. Thus, fishing communities are not merely defined by their geographical locations; they are dynamic systems shaped by cultural, social, and economic factors that extend beyond the boundaries of place-based definitions. Also, at-sea, land-based geographies differ, as fishers from different regions often share knowledge associated with specific fishing grounds. Consequently, relying solely on landing port data as proxies for mapping can lead to inaccuracies in understanding actual fishing practices and community dynamics. However, using landing ports as proxies in EOs provides a practical starting point, which has prompted further discussions about the role of fishing in coastal communities and the need for more detailed, community-specific data collection and research methods.

Effective incorporation of fishing communities into management requires considering their land-sea, social, cultural, and practice-based dimensions. The integration of fishing communities into the ICES advisory framework is a key step towards a more comprehensive understanding of marine ecosystems and the socio-economic dynamics of fishing. As technology and policy evolve, small-scale and non-commercial fisheries can also be included, making ICES data more inclusive. Anticipated advancements in Europe, related to the development of social indicators, fisheries and community profiles as part of collaborative efforts between ICES and STECF expert groups, will enhance our insights into the community characteristics and performance. This is crucial as fisheries are facing rapid changes due to changes at sea, such as the development of offshore renewable energy, and impacts of climate change. Integration into ICES advice, including future interactive products, will improve the assessment of policy and environmental impacts on communities, aiding policy decisions that balance competing interests.

The Celtic Sea and Greater North Sea fishing community maps are a foundational effort to visualize the social and economic role of fishing. WGSOCIAL's collaboration within ICES has set the stage for more comprehensive fisheries management, emphasizing the importance of fishing communities within marine social-ecological systems. Continued research and innovation will ensure fishing communities are central to sustainable and resilient fisheries management in the future.

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Author contribution

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Data availability

The Regional DataBase (RDB) is a regionally coordinated database platform for fisheries assessments. The database covers fisheries in the North Atlantic Ocean, the North Sea, and the Baltic Sea. Currently, access to the database is by login. The licence describes its access (ICES 2023a). Data on harbours coordinates was put together from open sources and will be shared upon demand. Economic data from EU countries are publicly available on https://stecf.ec.europa.eu/data-dissemination/aer_en.

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