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Reflecting on the importance of open communication and social capital for the co-creation of knowledge in Irish fisheries

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Fishing industry stakeholders have unique and important contributions to make to fisheries research. Co-operative and collaborative research approaches between science and industry are important to facilitate the documentation of fishers' knowledge and the co-creation of common understandings. Successful collaborations require open communication, trust and social capital, but numerous barriers exist to establishing these effective partnerships. This paper takes a narrative approach to reflect on the authors' experiences of engaging and collaborating with Irish fishers in the quest for the co-creation of knowledge, while considering how data from industry can best be used and integrated into scientific processes. This includes reflecting on barriers faced, in addition to motives and opportunities that have enabled this work to progress. Through case study examples, we reflect on issues surrounding misunderstandings regarding the roles of scientists and the scientific process, a lack of transparency, a lack of trust, historical/legacy issues, and contemporary pressures including the COVID-19 pandemic and impacts of Brexit. Building trust and active communication are identified as key elements to effectively co-create knowledge and common understanding. Trust is often developed in an informal setting, but more formalized processes, increased transparency and opportunities to engage, and institutional supports may further facilitate effective knowledge co-creation in fisheries.

KEYWORDS

social capital, trust, industry-science partnerships, stakeholders, fishers' experiential knowledge

1 Introduction

Fisheries science is an interdisciplinary field and industry stakeholders, along with academics and, government employees, have unique and valuable contributions to make to this domain (Stephenson et al., 2016; Thompson et al., 2019). While opportunities for fishers to contribute knowledge to fisheries science may have previously been limited, the

involvement of stakeholders is increasingly seen as a key aspect of good governance and is recognized as an important component of ecosystem based fisheries management (EBFM) throughout the world (Silvano and Valbo-Jørgensen, 2008; Fischer et al., 2015; United Nations, 2015; Mackinson and Holm, 2020; Mackinson, 2022). Fisheries represent complex systems occurring in dynamic environments and all additional information is likely to help ensure successful management (Dörner et al., 2015). Multiple sources of information are therefore required to achieve the aims of EBFM, and gain a fuller understanding of fisheries and their associated ecosystems, with fishers representing one important source of such knowledge (Thompson et al., 2019).

Fishers' knowledge includes more than just fisheries information and can include ecological and socio-economic data in addition to knowledge of gear technology and development and experience of various fisheries management schemes (Stead et al., 2006; Stephenson et al., 2016; Feekings et al., 2019), all of which are important to improve fisheries knowledge and to help address complex management requirements (Thompson et al., 2019). Fishers can impart knowledge through fisheries-dependent data collection in addition to sharing their own experiential knowledge (referred to as Fishers' Experiential Knowledge or FEK throughout this paper). In some fisheries there are long legacies of such data collection including; the Norwegian reference fleet (Nedreaas et al., 2006), self-sampling in fisheries in the Netherlands (Kraan et al., 2013) and the Northeast Fisheries Science Centre study fleet in the United States (Blackburn, 2017). There are also increasing examples of the documentation and application of FEK including a re-evaluation of Redfish catches in Canadian east coast fisheries (Duplisea, 2018) and of using fisher's knowledge to co-create indicators of food web structure in the Irish sea (Bentley et al., 2019a).

Collaboration, co-operative research and the co-creation of knowledge between science and industry are important in facilitating the documentation of fishers' knowledge and subsequently including FEK in science, research and advice. There is a spectrum upon which fishers can be involved in scientific research and as to how FEK is subsequently used. This ranges from fisher's acting as 'data collectors' and FEK being documented in a standardised manner to fit in with conventional fisheries monitoring data, through to fully participatory research where fishers are full time partners on projects and contribute to the development of research questions, hypotheses, design and execution of research (Stanley and Rice, 2017). While the outcomes of different science-industry partnerships may vary, such partnerships can result in both an increase in data collection and increased communication, transparency, capacity building, and trust between fishers and scientists (Kraan et al., 2013). Indeed, the objectives of many science-industry partnerships are to improve trust while delivering comprehensive, cost effective methods of data collection and data documentation that can strengthen the societal relevance of fisheries research (De Boois et al., 2021). Integrated research is also important, with scientists from a range of disciplines (including natural and social sciences), varied stakeholders, and decision-makers collaborating from the initial planning and design of research projects through to their completion. This helps to ensure transparency, mutual consent and understanding of research topics, management of expectations, tailoring of outputs, and critically, that data is used appropriately to support advice and management, and to enable fishers to understand and contribute to strengthening the scientific knowledge base (Mauser et al., 2013; Dörner et al., 2015; De Boois et al., 2021).

While partnerships between fishers and scientists are regarded as being an essential part of both fisheries science and management, these collaborations often require social capital to be successful (Armstrong et al., 2013). Social capital describes the social norms, networks, and bonds that facilitate co-operation, exchange, and reciprocity among and between groups of individuals, and is important to promote trust and improve cooperation among fishers (Pretty and Ward, 2001; Grafton, 2005; Barnes-Mauthe et al., 2015). Social capital among stakeholders is particularly important in socio-ecological systems which involve a diversity of actors and individuals (Barnes-Mauthe et al., 2015). A lack of trust and support between industry, scientists, and managers frequently leads to low participation in collaborative efforts, limiting the impact of industry data and knowledge on current science and management practices (Mangi et al., 2018).

Numerous challenges exist to building effective partnerships for co-creating knowledge in fisheries. The level of social capital required is also likely to vary depending on the exact role of fishers within a science-industry partnership. While advances are being made in the use of FEK in fisheries science there is no 'one size fits all' approach to overcome these and succeed in co-creating knowledge with stakeholders. In this paper we reflect on experiences in Irish fisheries in this pursuit. Taking a narrative approach, we reflect on engaging and working with Irish fishers in a quest for the co-creation of knowledge through a number of different initiatives. Barriers to such collaboration are highlighted while also considering the motives and opportunities that have allowed these initiatives to progress. Through a series of case study examples we identify key elements required for the co-creation of knowledge in Irish fisheries and how open communication, trust, and social capital were built in these examples. This provides insight that could aid the development of future collaborations, co-operative research projects and management efforts.

2 Case studies

2.1 Irish industry interviews: DiscardLess and RTI

Nineteen semi-structured interviews and small group discussions, documenting opinions and experiences from 21 fishers and industry stakeholders working in the demersal fishing industry, were conducted between July 2016 and September 2017 (Calderwood et al., 2021a). Interviews followed a set of questions which were originally designed to open up discussion around issues surrounding the introduction of the EU's Landing Obligation (DiscardLess project 2015-2020; Calderwood et al., 2021a) in addition to views regarding the potential adoption of Real Time Incentives (RTI) in Irish fisheries (Calderwood et al., 2021a; Pedreschi et al., 2021). By using open-ended questions and adopting a flexible approach (Ritchie et al., 2003; Longhurst, 2010) interviews were not restricted to these topics, however, and opinions were elicited in relation to current management systems, selectivity measures in fisheries and individual's experiences of optimizing catches in line with available quotas, issues and obstacles faced by individuals, and opportunities for improvement within Irish fisheries (Pedreschi et al., 2021). By taking part in these interviews, participating fishers provided a supporting role to the DiscardLess and RTI projects, sharing experiences, opinions and insights that later shaped the direction of research within these two projects and contributing to project outcomes.

Contact with interviewees were made through a number of approaches including *via* producer organizations, though snowball sampling methods (Naderifar et al., 2017) and by directly approaching individuals at harbours around Ireland. Interviews were conducted at locations most convenient to interviewees, which included offices, bars, hotels, homes, and the quayside (Calderwood et al., 2021a). Interview protocols were explained to all participants prior to interviews with corresponding signed consent forms collected. Where permission was given, interviews were audio recorded and later transcribed in full. Where interviewees chose to take part in interviews but not to be recorded notes were taken by hand during the interview. All interviews were anonymized but interviewees represented shore-based managers, co-op managers, officials from fisher representative bodies, and ex-fishers, although the majority were active skippers and vessel owner-operators. All but one individual were male. Vessels represented by the interviewees ranged from between 7 and 38 m in length with the majority of these vessels (77%) being members of the general polyvalent fleet segment. The Irish polyvalent fleet includes multi-purpose vessels of all sizes, including small inshore netters and potters through to medium and large offshore vessels, targeting demersal fish, pelagic fish, crustaceans, and bivalve molluscs.

Interviews were coded for conventional content analysis (Hsieh and Shannon, 2005) using the online software Dedoose (2018: Version 8.0.35) (Dedoose, 2018). Coding was carried out by a single coder (DP) to minimize variability in code application, with coding being reviewed by a second person (JC) to ensure consistency. Codes were assigned under general themes relating to the topics brought up during the interviews (Ryan and Bernard, 2003). Interviews and original associated codes (as detailed in (Pedreschi et al., 2021), were re-examined to identify topics related to trust, communication and fishers contributing their experiential knowledge to the scientific process. Additionally, interviews were examined to determine how fishers view the role of scientists and the scientific process within fisheries management. Outputs from this work were reported back to the fishing industry *via* project websites and publications in industry magazines (Calderwood, 2020).

2.2 At sea commercial catch sampling

Since 1993 the Marine Institute has been working with the Irish fishing industry in the collection of catch data at sea, aboard commercial vessels, under the At Sea Sampling Program. The fishers bring trained samplers to sea for the duration of the fishing trip and facilitate the sampling of the catch by providing a safe working environment to allow the sampler to collect the data according to internationally agreed standard operating procedures (Borges et al., 2004). The fishers do not get financially compensated for having the sampler aboard, as it is seen as the industry's contribution to the collection of scientific data. In the wake of the Covid-19 restrictions many nations suspended their Sampler At-Sea Programs. In Ireland the industry and the Marine Institute fisheries scientists worked together to mitigate for the resulting reduction of scientific data collected at sea by developing an At-Sea Self-Sampling Program. On inception the standard operating procedure (SOP) and associated datasheets and sampling pack were developed by MI Scientists in conjunction with active fishers. Prior to a full roll out of the scheme the At Sea Self-Sampling SOP and sampling pack was trialled by a participating vessel with feedback incorporated into further development prior to official roll out.

The At Sea Self-Sampling Program asks participating skippers and crews to collect data and samples from a subset of the hauls and bring the material ashore where Marine Institute fisheries scientists measure and record the associated data. Each vessel is contacted individually in advance of a possible trip following the statistically sound sampling protocol employed in Ireland since 2016 (Marine Institute, 2017). Once agreed, the participating skipper is trained remotely and supplied with a sampling pack pre-sailing. Participating skippers record haul start & stop positions, date and time, estimate the bulk catch and record the wanted catch by kg per species. One random box of unwanted catch is taken from the same haul for measurement ashore by Marine Institute

scientists. Observations on bird, mammal and reptile interactions are also recorded by the skipper. While at sea the participating skipper maintains contact with the Marine Institute's Fisheries Liaison Team Lead and quality assurance (QA) checks are performed during the trip *via* WhatsApp. The skippers provide *in situ* photographs of the datasheets with collected data and act as appropriate following clarification of the scientific QA feedback. Within this initiative skippers play an essential and active role, collecting and providing important data and samples to the Marine Institute regarding their catches.

2.3 WKIRISH

WKIRISH was a series of ICES sponsored benchmark workshops to examine why key stocks in the Irish Sea (e.g. cod, haddock and whiting) had failed to recover despite specific management plans and a substantial reduction in fishing effort. The initial driver for these workshops came from the North Western Waters Advisory Council (NWWAC). The Advisory Councils were set up by the European Commission (EC) to include both industry and eNGO stakeholders. Their role was to advise the EC on fisheries related issues. NWWAC asked ICES if it could investigate why there had been no recovery, and what could be done about it. The analysis included the construction of an ecosystem model (Ecopath with Ecosim – EwE) to explore the role of fishery and ecosystem drivers in the observed stock changes. Some of the data needed came from existing fishery and ecosystem data held by the Marine Institute. However, the base year for the EwE model was 1975, and data for elements such as fish diets for that year, and effort trajectories before 2003 were not available. These data were then reconstructed on the basis of the FEK from the industry participants and used in the model (as detailed in (ICES, 2016; Bentley et al., 2019a; Bentley et al., 2019b)). The model fit to the empirical data was substantially improved by this approach, as was the predictive power. Subsequently, the model was used to explore options for management with the active engagement of the stakeholders. Their confidence in the value of the model was substantially improved by their role in its construction, and then the questions asked of it. As a consequence, the stakeholders supported the conclusions, and actively and positively engaged with the management solutions that were proposed (Bentley, 2020; Bentley et al., 2021).

2.4 IFISH project

The IFISH (Irish Fisheries Information Sharing Network Development) project began in 2020 (running until 2024) with the aims of investigating how new technologies and mobile phone apps could be used to share real-time information to help skippers avoid unwanted catches and reduce discards (IFISH, 2021). The objectives of this project include improving understanding of fisher's bycatch avoidance strategies and adopting a stakeholder driven approach to develop peer-to-peer information sharing so that hotspots of juvenile and non-quota species can be identified in near real time. Documenting and utilizing FEK is crucial to the success of the project, to ensure any tools and apps developed meet industry needs and properly address issues and problems faced in daily fishing operations. To meet its objectives, the project aimed to first use semi-structured interviews and discrete choice experiments to determine how fishers value and target different components of the catch. Further, a co-design approach is central to the project, to collectively develop novel information sharing tools alongside stakeholders. Utilizing open dialogue and fostering two-way relationships with industry to co-design an information sharing app is key to the project's success. While this project was designed by scientists, it was developed based on conversations with industry regarding the need for more up to date information to make static fisheries hotspot maps more useful to them (Calderwood et al., 2019). Close collaboration with industry organisations including producer organisations and seafood advisory companies has been key to developing this work with representatives from such organisations having a significant role in the development of the project work with regard to developing information sharing initiatives with fishers

2.5 Mission Atlantic project

Mission Atlantic (missionatlantic.eu) is an EU-funded project, running from 2020 until 2025, that aims to map and assess the present and future status of Atlantic marine ecosystems under the influence of climate change and anthropogenic exploitation. Through seven regional case studies, one of which is the Celtic Sea case study, along with a whole Atlantic assessment, Mission Atlantic is developing and progressing integrated ecosystem assessments (IEAs) (Levin et al., 2014). IEA consists of a series of steps, the first and most critical of which is scoping with stakeholders. This process allows the identification of key current and emerging issues of concern and regional relevance, and directs and prioritises research, advice production, and management efforts.

Originally stakeholder engagement for Mission Atlantic was planned as a series of in-person interactive workshops to carry out the scoping, co-develop the risk assessment exercises, specify modelling scenarios, and enhance understanding of the socio-ecological system. Due to the COVID-19 pandemic, these initial plans had to be adapted to an online forum, and methodologies and planned interactions changed to accommodate this. Stakeholders within Mission Atlantic Celtic Sea cases study (to date) range from fishing industry representatives to eNGO and conserveation agencies, management bodies, and scientific research and advice agencies. Stakeholders from Ireland, UK, France and Spain have

participated in the meetings. Stakeholders are consulted throughout the project, contributing knowledge on active sectors and pressures within the region, ground-truthing results, contributing to conceptual models, and identifying key questions and scenarios for investigation. In this way the stakeholders contribute knowledge and understanding, and also act as the 'clients' of the IEA work, directing effort to ensure relevance and applicability.

2.6 Irish fisheries science research partnership

The Irish Fisheries Science Research Partnership (IFSRP) was first established in 2008 to help build and support collaborative industry-science partnerships and provide a platform for open communication and dialogue between fishing industry representatives and scientists at Ireland's Marine Institute and BIM (Bord Iascaigh Mhara - the Irish seafood development agency) (Marine Institute, 2020). At these meetings research projects, assessment results, research priorities, gear technology and gear development and industry concerns are actively discussed. A key aim of the group is to promote collaborative stakeholder engagement, which is deemed a cornerstone of the Ecosystem Approach to Fisheries Management.

3 Barriers to knowledge co-creation and subsequent mitigation

3.1 Institutional and legislative complexity

There are numerous bodies operating within Ireland involved in assessing fisheries, fisheries management and in enforcing rules and regulations.

Table 1 details individual bodies and government departments in Ireland that are responsible for the management, regulation and research of sea fisheries in Ireland. Much of the management and regulation of sea fisheries is directed by the requirements of the EU's Common Fisheries Policy (European Commission, 2021). In addition, there are the statutory responsibilities for the protection of the marine environment. The primary EU instrument for this is the Marine Strategy Framework Directive (MSFD: European Commission, 2008), whose implementation falls to Department of Housing, Local Government and Heritage. The science and research supporting MSFD reporting comes from a range of national sources. The EU Maritime Spatial Planning Directive (MSPD: European Union, 2014) is responsible for planning spatial use of the sea, and falls under the competency of the Department of Housing, Local Government and Heritage (DHLGH). While these two directives may not directly impact upon fishers' day-to-day work (unlike the CFP), they are relevant to their interests, and add to the complexity of the marine institutional structure within Ireland. Several additional departments are also involved in MSFD & MSPD including the Department of Transport, and the Department of Tourism, Culture, Arts, Gaeltacht, Sport and Media. The Department of the Environment, Climate and Communications (DECC) is also relevant, particularly under the changing landscape due to climate change and the current expansion of offshore renewable energy (ORE). While MARA (Maritime Area Regulatory Authority), a newly established authority for Maritime Area Consent, is also in the legislative landscape in relation to offshore renewable energy (ORE) (Semple, 2021).

With these various bodies operating in the same space it can lead to confusion as to who is responsible for what (Figure 1), especially with regard to how fisheries scientists fit in within this landscape. Regarding the Marine Institute specifically, one interviewee explained '*A lot of the problem is fishermen don't know what the Marine Institute is doing*'. When any of the marine management authorities were brought up in interviews with fishers there were a number of examples where they were lumped together, misidentified or regarded as one and the same with various themes related to 'complexity', 'simplicity', 'legislation' and 'regulation' being identified in interviews. One fisher, for example, was explaining the amount of regulations and paper work required day to day to operate a fishing vessel and said '*The hassle, the food hygiene, the SFPA stuff, the Marine Institute … The Navy … And then you have BIM*'. While some fishers indicated that they understood the scientific role of the Marine Institute in terms of the survey work, data collection and stock assessments performed by its' staff, its links with DAFM often remained the over-riding factor, with a fisher explaining, '*Look, whether you like it or not, right, you guys are with the Marine Institute, they [DAFM] are still your bosses*'. This can further result in distrust with one fisher explaining '*the likes of the distrust that we've been talking about, not necessarily between individual fishermen, but between fishermen and the scientists, and the scientists and the department, and the department and the fishermen*'. The problem of conflation between the science and management bodies is a perceived loss of independence which means that a dissatisfaction with management processes can directly affect an individual's willingness to engage in scientific research if they believe they are one and the same, or mistake them for one another. It has also been recognized that if scientists wear too many hats or take on too many roles it can create confusion regarding their roles, undermining trust from industry (Mackinson et al., 2011). Certainly the work of scientists at the Marine Institute feeds into policy and advice, which likely contributes to the blurred understanding of their roles. This misunderstanding of roles and distrust of scientists has created barriers that need to be broken down prior to working and collaborating effectively with industry (see Section 3.2). Institutional and legislative complexity have also been identified as key barriers to the implementation of the Ecosystems Approach to Fisheries Management (EAFM)

TABLE 1 Bodies and departments within Ireland that have responsibilities in relation to Irish fisheries.

Body	Relation to other bodies	Responsibility
DAFM (Department of Agriculture, Food and the Marine)	Irish government department	- The Sea Fisheries Policy and Management Division within the Department of Agriculture, Food and the Marine (DAFM) is responsible for fisheries management in Ireland (Brennan, 2022) -Manages Ireland's licensing and quota in line with the EU's common fisheries policy (CFP) (DAFM, 2016; Calderwood and Reid, 2019)
SFPA (Sea-Fisheries Protection Authority)	Independent statutory body	-Responsible for regulation of sea fisheries -Responsible for protecting and conserving fisheries resources for long-term use -Promotes compliance with sea fisheries legislation (including CFP) -Verify and enforce compliance where necessary -Monitors and enforces seafood safety
Irish Navy		-Collects VMS data for use by the SFPA -Conduct on-board inspections of fishing vessels in Irish waters
Marine Institute	State agency	-Provides scientific and technical advice to the government to help inform policy and to support the sustainable development of Ireland's marine resources - conducts fisheries surveys and collects fisheries data to provide advice that underpins the fisheries management framework - Scientists at the Marine Institute also conduct research to support an ecosystem based approach to fisheries management
Bord Iascaigh Mhara (BIM)	State agency	- responsible for developing the Irish Seafood Industry -BIM leads on industry training, collection of economic data, seafood processing and marketing, sustainability training and certification, gear technology, and administration of grant-aid and project funding directly to the fisheries and aquaculture sector
Inland fisheries Ireland (IFI)	State agency	- protects, manages and conserves Ireland's inland fisheries and sea angling resources, which includes the 12 mile coastal jurisdiction - research and management of diadromous species
Marine Survey Office (MSO)	A body within the Irish Maritime Administration, Housed within the Irish government's Department of Transport	-responsible for the implementation of all national and international legislation in relation to safety of shipping and the prevention of pollution of the marine environment from ship-based source - regulates the living and working conditions of all Irish ships and crews and foreign flagged ships and crews in Irish ports and the security of Irish ports -grants initial approval of designs and drawings for new vessels or modifications to existing vessels - provides surveys for certification of modified vessels
Mercantile Marine Office (MMO)	A body within the Irish Maritime Administration, Housed within the Irish government's Department of Transport	- maintains a General Register of Shipping -assists vessel owners with all aspects of Ship Registration and activities such as surveys and issuing of Ship Radio Licenses and maintaining the Seafarers Information System and website, assisting seafarers with all aspects of applications for certification

(Young, 1998; Ramírez-Monsalve et al., 2016), a stated goal of the European Commission (European Commission, 2008; European Commission, 2013). It is essential that institutional structures allow for interaction and facilitate stakeholder involvement, a key aspect of EAFM, and of ecosystem-based management (EBM) of socio-ecological systems (Stringer et al., 2006; Mackinson et al., 2011). Complexity can be overwhelming and act as a barrier to such interactions, and while as fisheries scientists we have limited ability to reduce institutional and legislative complexity we can increase trust and social capital between ourselves and fishers by better explaining and communicating our work and role to industry stakeholders.

Many fishers that had a more complete understanding of the work and role of the Marine Institute often had experience of working alongside its' staff, either during sampling work or research projects, illustrating the importance of direct engagement and experiential learning. Reaching a wider audience and finding more opportunities for fishers to work with marine scientists, through research projects as well as schemes such as At Sea Self-Sampling, are therefore increasingly important to build further trust and understanding between scientists and fishers. Fora such as IFSRP also provide industry with insight into the role of the Marine Institute, highlighting the research scientists at the organization are involved in and gives fishers an opportunity to guide the Marine Institute and BIM toward further research to benefit the industry. It is critically important however, for this knowledge to be spread beyond the few industry representatives present at these meetings if a fuller understanding of the work and role of Marine Institute scientists is to spread across the fishing industry. Avenues to reach fishers who are not members of Producer Organisations (POs), co-operatives, RIFFs (Regional

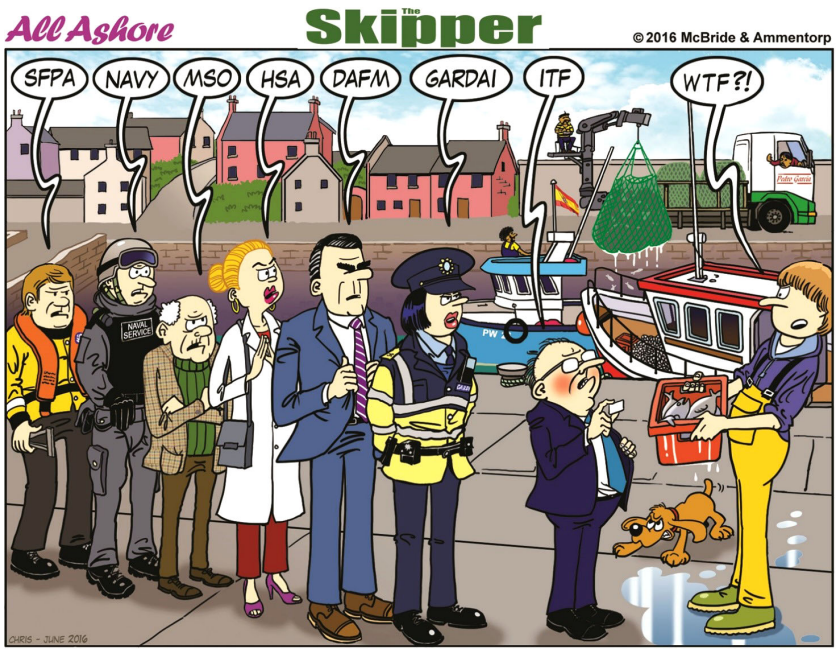

FIGURE 1
Cartoon taken from The Skipper, a leading journal for the Irish and UK fishing industries, reflecting industry confusion over the number of different agencies they are required to interact with. (Image provided courtesy of The Skipper - https://theskipper.ie/).

Inshore Fisheries Forums) and the NIFF (National Inshore Fisheries Forum) also need to be developed and maintained, as within Ireland it is not mandatory for fishers to be members of representative bodies such as PO's.

3.2 Misunderstanding and mistrust of scientific sampling methods and the stock assessment process

A lack of understanding of scientific sampling methods and, particularly, the stock assessment process represent further barriers to building the trust and social capital required to facilitate knowledge co-creation in Irish fisheries (Pálsson, 1995). Fishers can often see the broad importance of fisheries science, with one telling us '*I think there is a lot of people realize that the science arm of things is very important and you need [to] cooperate and all that*'. Yet there is less understanding and support of the science that supports stock assessments. This is unsurprising given their technical nature. Even though there have been large improvements in recent years in making the stock assessments more transparent, they remain a specialist subject. Indeed, transparency can, in some cases, contribute to eroding trust, when observers note some of the assumptions that are included in even the most simple of models. 'Trust' was a theme identified in interviews, relating to numerous relationships including those between fishers, with scientists and with managers but simply, we have often been told that '*I don't trust the science*'. This lack of trust is related to a number of different elements.

Firstly, there is a lack of trust in the sampling stratification of fisheries surveys carried out on research vessels. While fishers target activity where they know they are likely to encounter fish, scientific surveys are designed to find information about the fish population as a whole in an area and survey both where there are and there are not concentrations of species, tracking changes in distributions. These different perspectives often result in differing opinions with regard to the status of fish stocks, which can ultimately erode relationships between fishers and scientists (Mackinson and van der Kooij, 2006). Essentially the scientific sampling methodology is often seen by industry stakeholders as wrong. Comments are often made regarding surveys taking place at times or in locations where there aren't any fish, and how fishers could show scientists where to catch various species. This includes comments such as '*what's the point in doing the science later in the year when all the fish has spawned and moved on*', '*They're scientists, I'm a fisherman, but I can see all the juveniles on the ground when we haul pots and stuff. They tell me they're not there*' and '*it took them 5 years to realise the herring is here. Like it comes out of the Bristol Channel or in The Smalls. They are still doing surveys down in the north of The Trench down towards the top of the Labadie Bank where there hasn't been herrings in 6 years*'. While this highlights the tension between FEK and scientific knowledge, it also shows the strong potential for FEK and industry data to complement and contribute to the scientific data. To achieve this, we need to

improve understanding of why, as scientists, we adopt the survey methods that we use. Explaining sampling using simple analogies such as '*you wouldn't estimate the population of Ireland by counting people in the City Centre in Dublin and scaling up from there*' can be useful to communicate such ideas. The possibility of incorporating a small module on fisheries science and associated sampling methods into BIM's Skipper Full Certificate of Competency training course (BIM, 2022) could also be of real benefit to further communicate this message. This would build on individual presentations delivered by Marine Institute staff (entitled 'Fishing for Science – From Deck to Desk and Back) which have been delivered to skippers in training in Ireland.

Even with a fuller understanding of sampling and stock assessment methods, when scientific advice and quotas do not match with what fishers are seeing in their nets this can lead to further frustration and a disincentive to contribute their own data to the scientific process. Interviewees raised a number of specific examples where they were seeing more fish on the ground than was represented by available quota. Even when there is an understanding that the provision of more information could improve stock assessments there can be a reluctance to contribute if the outcomes aren't likely to be favorable to fishers. This is highlighted by the following quote, *'it's just the way the scientists look at the information … we could improve it and get more information, but it almost always has a negative impact on the industry, that's the perception*'. This opinion represents a fear of data, with data provided by fishers being taken out of context or being used where it could have a negative impact on the fishing industry (Ebel et al., 2018). This also links to confusion between TAC, which is determined based on stock abundance and closely related to the science, which then leads to national quota, which is in turn allocated to individual vessels subject to policy decisions. While science gives advice on the state of the stocks and possible TAC, politics sets the actual TAC and policy sets the quota, but fishers relate the quotas they have available to them back to the science and this can lead to challenges when building effective working relationships, as detailed more in section 3.3.

Secondly, some fishing stakeholders don't realise that their logbook and VMS data contribute directly to the stock assessments. Prior to the full implementation of the Landing Obligation one interviewee frankly stated: '*your model will be rubbish if based on logged catch data'*. This is an extremely important disconnect, as when fishers perceive their reporting as contributing only to their monitoring and enforcement, it provides perverse incentives for misreporting (Gallic and Cox, 2006; Hentati-Sundberg et al., 2014). More work is required, therefore, to build trust and understanding so that fishers do not feel that they will be penalized by providing accurate catch information, but instead that they can actively contribute to the scientific process, more accurate stock assessments and successful EBFM. An example that could benefit from more reporting of catches from fishers is that of the North East Atlantic stock of spurdog (*Squalus acanthias*). This stock has been assessed as being historically low and has been subject to zero TAC throughout EU waters since 2010 (European Commission, 2015; Fox, 2015). While fishers have anecdotally reported increases in spurdog in recent years a lack of fleet-based data and reliable catch information since 2010 have been recognized as weaknesses in recent stock assessments (ICES, 2021) Due to their zero TAC status any spurdog caught in Irish fisheries should be recorded in logbooks as discards before being released in case of survival. However, active avoidance of this species is encouraged and some fishers have explained that they know where they could catch spurdog but they avoid these areas so have no records to submit that could aid benchmark assessments for this species. Others, who incidentally catch spurdog may not log it as a discard for fear of fishing grounds being closed as a result. Without more accurate catch information, however, it is difficult to fully assess the fishers' claims that spurdog numbers are increasing. A recent benchmark and subsequent ICES assessment in 2022 has shown an increase in the stock size which may lead to a non zero TAC (ICES, 2021; Institute, M. 2022).

One way to break down barriers and foster trust in the science is to improve understanding of the work and role of scientists (Dedual et al., 2013). The use of direct experience has previously been shown to help build social capital (Bailey et al., 2017), with a lack of trust often being more evident when there is limited contact between fishers and scientists (Glenn et al., 2012). A lack of opportunities for fishers to engage in the scientific process and gain positive reinforcement regarding this have been noted however, especially within European fisheries (Mackinson et al., 2011). The Irish At Sea Self-Sampling Program is, however, one such example which has proven to be a great vehicle to educate a wider distribution of fishers of the scientific process of gathering and collating raw data. As stated a common complaint of fishers is that the "*science is way behind what we see on the ground*". The At Sea Self-Sampling Program allows fishers to feed in their knowledge in a format that can be directly used in the scientific process. The fact that the At Sea Self-Sampling Program samples a subset of what a Sampler At Sea might collect also highlights the utility of taking trained scientists to sea. WKIRISH also provides an example of fishers and fishing industry representatives working alongside scientists to help improve understanding of the scientific process from the industry point of view while utilizing fishers' knowledge to improve our understanding of marine ecosystem functioning (Bentley et al., 2019a). In this instance the initiative began following requests from the fishing industry to provide a benchmark for the Irish Sea, after poor recovery of whitefish stocks in the area were noted. From a request from industry grew a collaborative endeavor that has certainly built trust and social capital, with industry valuing efforts from scientists to address and answer their concerns,

while building understanding from different perspectives for all those involved in the process.

Inviting fishers to work alongside scientists during the planning and implementation of surveys can also be a useful way to build understanding of scientific sampling methods. In the mid 2000's there was a perception that the Celtic Sea Herring assessment was wrong, as the fishers felt that the survey was not being conducted in a manner that made sense, given recent changes in distribution etc … To help the fishers get a better understanding of the scientific process a representative fisher (nominated by the fleet) sailed on the scientific survey as an observer with specialist FEK to report back to the industry on the survey. The feedback from the "observer fisher" reported that the fisheries scientists had adapted the survey to reflect recent spatial changes but had done this in a manner that did not compromise on the scientific integrity of the survey time series. A radical change as expected by some fishers would have severely compromised the survey time series. An appreciation of this fact from survey participation led to a greater understanding which the observer fisher was able to communicate to fellow fishers on return. Collaborative experiences, outside of directly working together on surveys and research vessels, can also help improve understanding of the scientific process, including individual knowledge and experience sharing (e.g. IFISH, RTI, DiscardLess), and *via* participation in group workshops and discussion fora (e.g. Mission Atlantic, IFSRP). This improved understanding has been demonstrated where stakeholders that have repeatedly engaged in research fora feel empowered and comfortable to speak knowledgably about ecosystem-based fisheries management (EBFM) in other fora (e.g. in discussions about ORE). From our experiences those individuals who have been engaged in research previously, having gained an understanding of the science and scientific process, are more likely to engage in further scientific research. This may be in part because these individuals are naturally more inclined to engage with scientists due to their own curiosity, enjoyment of the experience, a desire to have more of a say in research and research outcomes, or to stay abreast of the latest developments in research. Working alongside scientists, either supporting survey work, attending science-industry partnership meetings, or being directly involved in research activities, may in itself not be sufficient in providing a full understanding of what fisheries scientists do. One fisher involved in research trips and tagging studies explained '*I don't find the results of it and like there has never been any follow up cod tagging programmes*'. A number of cod tagging programmes have been run by the Marine Institute in close collaboration with industry. These include an industry led initiative around the Greencastle codling fishery, which led to the closure of a winter fishery for juvenile cod (Ó Cuaig and Officer, 2007; Lordan et al., 2011), a Celtic Sea cod tagging programme which provided valuable insight into migration patterns of juvenile cod (Lordan et al., 2011) and a cod tagging study in the Irish Sea to determine mortality sources on cod in this sea area (Lundy, M et al., 2022). In these instances, follow up tagging programmes were not deemed necessary at the time as study objectives were met, so the lack of follow up referred to by the fisher could relate to a lack of accessible results or lack of feedback of results back to industry, as well as the fisher having different expectations of the outcome of the work they were involved in compared to the scientists. It is acknowledged in these cod tagging studies that the enthusiastic response of participating skippers was key to their success and furtive information exchange was achieved (Lordan et al., 2011). But it remains important for all partners to have a full understanding of involvement in research if social capital is to be maintained and not eroded. Indeed, levels of good quality communication are shown to relate to trust between fishers and scientists (Glenn et al., 2012). Thus, there remains a need for improving communication and engagement between scientists and industry to develop understanding and solidify existing collaborations. This has been achieved on a project level (e.g. RTI and DiscardLess) through the use of email newsletter updates. The Marine Institute also has an open access repository of all the research outputs from its' scientists. Resources such as the Stock Book, an annual publication providing advice on commercially exploited fish stocks in Ireland in an easily accessible format is freely available and accessible on-line in pdf and shiny app format (shiny.marine.ie/stockbook) along with a digital interactive shiny app also providing results from Irelands annual ground fish survey in an interactive format (shiny.marine.ie/igfs). Further education and marketing may be required to better point to the information and resources available for fishers to freely access, as well as ensuring results are sent directly to any study participants. Again, a forum such as the IFSRP can be used to highlight recent publications and new on-line resources but effort needs to be made to ensure all fishers are aware of what is available on-line.

3.3 Legacy and contextual challenges

Even after making efforts to overcome issues regarding understanding of our roles as scientists and the scientific process, to build social capital between scientific and fishing communities, there are further concerns often outside of our control as fisheries scientists that can impact upon these working relationships. These include legacy issues, which may have a long rooted history before many of us started our scientific careers. But also current issues and contextual challenges that can affect the willingness of stakeholders to engage with scientists. Regardless of when pressures on fishers emerged, those that are currently impacting upon an individual's fishing operations or are of current concern will significantly impact upon co-operation, even if they have nothing to do with the management, science or the questions we are asking.

Legacy issues that are frequently mentioned when conversing with fishers, and are recurrent themes in interviews, include those surrounding relative stability, quotas and the operations of foreign vessels within the Irish economic exclusion zone (EEZ), and the management of these issues. Relative stability describes the distribution of fisheries resources between EU member fleets, with each member state receiving the same proportion of the available TAC year on year, based on historic fishing records (Symes, 1997; Morin, 2000; European Union, 2013). Prior to Brexit the Irish EEZ constitutes 10% of the EU EEZ with Irish vessels accounting for 42% of landings by weight and 36% of the average value of landings from this area (Department of Food Agriculture and the Marine, 2018). Some members of the Irish fishing industry feel the division of quotas for Irish vessels within their own EEZ is unfair, especially when they have limited quota for fishing in the waters of other jurisdictions. Fishers have described the situation in the Irish fleet as '*fighting over crumbs*'. These issues then came to the fore with the introduction of the EU's Landing Obligation and the risk of choke species (Schorpe, 2010; Catchpole et al., 2017; Calderwood et al., 2021b). Fishers complained that once their monthly quota allowance was used up in any month (Calderwood and Reid, 2019), and they faced a choke situation in any management area, other countries not subject to the same monthly quotas or choke would benefit, '*all the Irish boats will leave there and the Spanish and UK boats will be work away there you know*'.

These feelings of the unjust nature of quota allocations are further conflated by the perception that foreign vessels operating in Irish waters are not subject to the same levels of scrutiny from inspection agencies as Irish vessels. One fisher explained that they felt SFPA officers could only check that legal gear is being used on foreign vessels, but not check catch levels are in line with quota as they do for Irish vessels because '*the Irish authorities don't know what their quotas are because they can swap them*'. This also links to issues many in the industry had with the introduction of electronic logbooks for vessels greater than 12 meters in length (European Commission, 2011). Ireland was one of the first countries in the EU to implement the new legislation and have Irish vessels adopt e-logbooks, as opposed to the use of paper records. Fishers were encouraged to adopt the new system with promises of '*the Spanish will have to go through our hub and we'll know exactly what everybody has*'. But instead fishers have explained that '*soon as they put them in, we were the first boats to put them in, well actually the Spaniards and all the foreign boats don't go through our hub, we don't know what they're landing, they go straight to their own national hubs*'. This again leads to feelings that Irish vessels are disadvantaged fishing in their own waters compared to foreign vessels.

These issues are further linked to a belief that quotas do not reflect the reality observed on the ground (Pedreschi et al., 2021), as touched on in section 3.2. Frustrations arise when quotas are limited and fishers are not only seeing fish on the ground but see other nations catching them when they are not able to. Again this links to any one country or vessels' quota not necessarily reflecting the overall TAC for an area. Yet despite TACs being informed more by the science rather than policy, further distrust and frustration in the system arises with the specification and allocation of Total Allowable Catch (TAC) by the European Commission (EC) at the annual December Council, a historically political process. Years of setting TACs above the recommended scientific advice (Proelss and Houghton, 2012; Carpenter et al., 2016; Borges, 2018; Borges, 2021) has eroded trust in the system, including the science. All of these issues relating to relative stability, the perception that foreign vessels are faring better in Irish waters than the Irish fleet and a general mistrust of the TAC allocation system are entwined. As such they can be described as 'wicked problems' that pose a constant challenge and are difficult to delineate from other issues (Jentoft and Chuenpagdee, 2009). These problems can have long lasting effects on trust and also provide a disincentive to collaborate with scientists, as it is unlikely that results from scientific research can do much to address such legacy issues.

There are often more pressing issues, linked to management, socio-economics, politics and culture, that can also affect the willingness of stakeholders to engage. The impacts of Brexit on Irish fisheries have also been of particular concern in recent years and the uncertainty of the impacts this might have on the Irish fleet. Concerns of reduced quotas as the UK leaves the EU indeed led to Irish fishers protesting in both Cork and Dublin in 2021 (Burns, 2021; Halpin and Kilcoyne, 2021). For some industry representatives the expansions of offshore renewables is expected to have a greater detrimental effect on the fishing industry compared to Brexit (Duffy, 2022). Concerns stem from multiple stakeholders wanting to use the same marine areas with fishers feeling increasingly squeezed. Increasing fuel prices, which were exacerbated by the Russian invasion of Ukraine, are also having a significant impact on the fishing industry with the processing sector seeing knock-on impacts and costs increasing by 200% to 350% compared to the previous year (Forsythe, 2022). These larger, often international issues add to day-to-day challenges including the need for de-watering and weighing catches on the pier (Fagan, 2021), navigating penalty point systems (McCurry, 2021) and finding crew for fishing vessels.

Without immediate or obvious benefit from collaborating with scientists, in terms of addressing legacy and equity issues and contextual challenges, it can be hard to build trust and persuade fishers that there are benefits to contributing FEK and assist with research projects. It is critical that, prior to engagement with stakeholders, effort is made to understand what is affecting them, i.e. to understanding the context in which they are operating. While it may be difficult to enact change to address issues of concern, at the least as scientists we should take the time to listen to the concerns of the fishing industry. While we may have little influence on the things of

most concern to fishers, having a full understanding of the challenges and concerns of industry can shape and influence the direction of research and improve our understanding of fishing operations and the motivations of fishers. Taking such time to engage with fishers and build relationships is an essential step in our research programmes, even if not directly addressing research objectives, as open dialogue can be a way of documenting important FEK and putting our research into better context. When working with industry it is also important for scientists to acknowledge things we deem as important may not be as important to industry. While we should continue to pursue science that does have some industry support, it is important to understand this process may take longer than planned, especially when other issues and concerns come more to the forefront. It is critically important to discuss, explain and manage the expectations of all parties involved.

3.4 COVID-19 pandemic

Once such major contextual challenge was the unprecedented effects of the COVID-19 pandemic. COVID-19 has been recognized as having a significant impact on the fishing and aquaculture industries throughout the world (Ray, 2019; White et al., 2021; Alam et al., 2022). The requirements for social distancing in addition to both international and domestic travel restrictions (Kennelly et al., 2020) also impacted on the working patterns of fishers and fisheries scientists within Ireland. This included restricting the ability for at sea samplers to join fishing vessels to sample catches, and for research staff to visit ports to collect catch samples as part of our national sampling program, thus affecting the scientific data collected.

The temporary suspension of the At Sea Sampling program due to Covid-19 restrictions resulted in the development of the At Sea Self-Sampling Program as described above (Section 2.2). While the program resulted in less complete data than before Covid-19, it was still important. The alternative of zero At Sea data on catch composition, would have been seriously detrimental to the assessment process. The At Sea Self Sampling Program ensured that communication lines remained open even in times of limited mobility. The success of the program was due to the participants wish "to do it right" and the strong interaction between the associated scientists and fishers in the inception, development and implementation of the program. Further the effects of Covid-19 restrictions on shore based sampling was minimized by the facilitation of out of hours sampling by the processors and Marine Institute staff. Co-operation from industry to facilitate this sampling was important as the availability of fish to sample was affected by the knock on market pressures that the fleet experienced during Covid-19. In the example of the At Sea Self-Sampling Program the challenges of Covid-19 have actually provided opportunity to open up new avenues of working with industry to collect catch information. The success of the scheme, as seen from both Marine Institute and industry perspectives, has led to it continuing. The Marine Institute now incorporates the initiative into the national data collection program to augment the data collected by scientific samplers at sea under the original At Sea Sampling program. The combination of the dual data streams is expected to increase the number of observations at sea in an efficient and scientific manner, whilst also allowing vessels previously restricted due to accommodation limitations to participate in at sea sampling. Having such a positive result come out of a period of uncertainty for the fishing industry is a great achievement and an example of a successful collaboration between scientists and industry.

As well as impacting sampling, COVID-19 has also had an impact on the engagement of stakeholders with research projects (Köpsel et al., 2021). Travel restrictions and requirements for social distancing in Ireland in the first year of the COVID-19 pandemic impacted on a number of research projects running at the Marine Institute, including IFISH and Mission Atlantic (Sections 2.3 and 2.4). The initial plan for the IFISH project was to travel around Ireland to the main ports, engage with fishers and raise awareness of this new project, as well as conduct interviews to gauge understanding of how fishers value different components of their catches. For Mission Atlantic, in-person stakeholder meetings were planned for the Celtic Sea case study, which would involve participants from Ireland, France, and the UK. Within the first year of the pandemic Ireland's response included restriction on non-essential travel, with individuals being restricted to travel within 2km and then 5km from home, before being extended to 20km, and then county wide travel (Kennelly et al., 2020). During this time much international travel was also restricted, with individual organisations placing restrictions on employees in regards to 'unnecessary travel'. Even once country wide travel was allowed many indoor venues such as cafes and hotels, where we may have previously arranged to meet to chat to stakeholders, were closed. This made face-to-face meetings virtually impossible for many months, impinging on collaborative efforts. This unanticipated situation required adoption of different strategies to maintain engagement with relevant stakeholders. In addition to the obstacles presented by travel restrictions and social distancing measures, Ireland's seafood economy declined by 12% in 2020 compared to 2019, driven primarily by an 18% reduction in domestic consumption, due to the closure of many businesses in the hospitality industry, and an 8% decline in exports (Afloat, 2021; BIM, 2021). The pressures faced by industry during this time led to some fisheries representatives calling on the Irish government to provide supports for a temporary tie-up scheme to assist in dealing with the turmoil in the markets at this time (Mainnín, 2020). Such hardships

meant that willingness to engage in research projects was reduced as it was not seen as an immediate priority or as essential (Köpsel et al., 2021).

The IFISH project was just commencing at the outset of the pandemic but every effort was made to maintain open communication channels at this time to try and continue the research and preserve relationships with fishers. The project was advertised *via* social media and industry contacts were invited to participate *via* e-mail. Some interviews were conducted *via* phone and online video call services. While such approaches did aid in overcoming social distancing and travel restrictions, they didn't allow the time and environment to allow conversations to develop as had previously been experienced when conducting face to face interviews. The importance of pre-existing relationships was illustrated as approaching and engaging fishers we had previously worked with was more successful than trying to contact and arrange meetings with fishers we had not previously met in person. While progress was slower than anticipated due to the restrictions, and additional pressures facing the fishing industry, engagement was possible using on-line solutions. As restrictions began to lift, IFISH progressed from on-line meetings to planning in-person events to begin to facilitate focus group discussions on how app technology could be potentially be used to facilitate information sharing between vessels to reduce unwanted bycatch. However, at the time of writing these planned discussions have been postponed as fishers struggle to deal with the recent rises in fuel prices, general inflation, running costs, and crew shortages making it hard for some boats to get to sea and make a living (Moore, 2022). Despite these delays, industry representatives remain keen to pursue this work when the time is right.

For Mission Atlantic planned in-person stakeholder meetings had to be abandoned and replaced with online virtual meetings. This directly impacted the project as it dramatically reduced the time available, and the tasks that could be carried out. Initial plans involved a risk assessment exercise to be carried out with stakeholders. Previous experience had indicated that was a complex exercise, requiring active participation and discussion, with multiple facilitators, in a workshop carried out over a 2-3 days. Critical to its success is the downtime, and building of common understanding as well as group cohesiveness, which cannot be achieved to the same degree online. Furthermore, body language is impossible to read, and so it is more difficult to judge responses when seeking consensus, especially when participants may have their cameras turned off. We were also highly cognizant of the 'screen fatigue' and digital burnout that many were (and are) feeling throughout this period (Bennett et al., 2021; Pandya and Lodha, 2021; Sharma et al., 2021). As a result, we changed the initial exercise from an in-person co-production exercise to an on-line presentation of results and 'sanity-check' approach. In an attempt to avoid some of the common pitfalls of online meetings we encouraged contributions through a range of methods. Participants were free to ask questions at any time verbally or to write in the chat which was monitored by a meeting facilitator. The meeting was carried out under 'Chatham House Rules' where participants are free to use the information received during a meeting outside of the meeting, but not to identity the individual or the affiliation of the people that said it. This encourages some participants to speak more freely. Additionally, we created an online collaborative note-taking Google document with live-note taking by meeting facilitators, to which participants were also encouraged to contribute if they wished. In 2021 a full-day meeting was held where the risk assessment results were presented to stakeholders and discussed in detail. Stakeholders were made aware that this was an iterative process and they were free to suggest changes to the assessment. When the initial results were reviewed and discussed, an additional moderated discussion identified common stakeholder research questions relevant to the case study area. These questions and discussions are being used to direct research efforts in the Celtic Sea case study. In 2022, the same format was applied, except we broke the full day meeting into two half days to avoid information overload and provide time for reflection between sessions. During this meeting the focus was on providing updates, including presenting the modelling framework, defining scenarios that the stakeholders wish to be investigated, and carrying out an online group conceptual modelling exercise. Despite an in-person meeting still being the preferred approach for these meetings for the reasons outlined above, there was good engagement online, with valuable outputs created. With no travel costs and a reduced time commitment without additional travel requirements options for online attendance may have also increased opportunities for attendance. So far we have managed to mitigate against any major project delays through our adaptive and reflective approach.

Each project has been affected by the pandemic to different degrees. This may have been influenced by the type of stakeholder targeted. For Mission Atlantic, although in-person meetings were no longer possible, most of the stakeholders engaged were industry or eNGO representatives, or working for national agencies, and therefore had moved most of their work online. Conversely, the IFISH project is largely targeting individual fishers, whose livelihoods are more directly impacted by the difficulties imposed by the COVID-19 pandemic and rising inflation. As such, it is perhaps not surprising that it has been more difficult to progress the IFISH work under the current circumstances. Additionally, while online meetings do have the benefit of accessibility in theory, consideration must be given to the digital literacy of those you are engaging with, ensuring flexible and simple approaches for effective on-line engagement (Köpsel et al., 2021).

4 Discussion

It is widely acknowledged that fishing industry stakeholders have important and unique contributions to make to fisheries research. Despite advances being made in recognizing the importance of FEK within science and management, and in developing participatory research approaches, a number of barriers exist within Irish fisheries for successful co-creation of knowledge and integration of FEK into the science and management processes. Despite this, efforts by both scientists and fishery stakeholders continue to be made to overcome these barriers, build strong working relationships and foster these relationships for the co-creation of knowledge to advance research and further understanding of Irish fisheries.

Reflecting on our experiences of working together with fishers in Irish fisheries to co-create knowledge we have highlighted the importance of providing opportunities for fishers to work together with scientists to improve understanding of scientific processes and build trust in these. We also highlight the importance of scientists working with and learning from fishers to better inform our science and scientific practices. Two key elements when working together are maintaining regular open communication and allowing time for building trust and subsequently achieving desired outcomes from working together with industry. While the process of collaborating with industry might require time and patience, maintaining momentum and creating opportunities can also be key when establishing participatory research (Mackinson et al., 2011). The importance of social networks has been recognized as being important in the determination of social capital (Grafton, 2005). Strong ties between groups of fishers are often linked to trust and co-operation, but as scientists we need to improve 'linking' social capital, the connections that exist across disparate groups (Grafton, 2005). The networks we have already established, through previous outreach, sampling and survey work, and the case studies outlined herein, provide a solid foundation for continued and future work with industry. Working with those with whom we have already built trust and social capital is an important avenue to maintain momentum. While working with early adopters presents a classic approach to building social capital, we must also ensure that we don't overlook fishers who we haven't previously worked with, or who have fewer links to the Marine Institute, such as those who are not members of Producer Organizations. We must also consider the roles fishers want to take on within science-industry partnerships and how this may impact upon adoption. Many of the examples presented in this paper look at ways in which avenues are provided for fishers to contribute their knowledge once research programmes and initiatives have already been developed. If there were more opportunities to involve fishers from the outset of projects from question formation, hypothesis building and design there may be higher levels of satisfaction and pride in their participation, which then leads to higher social capital that could potentially encourage further participation. The legacy from the WKIRISH process certainly demonstrates how positive relationships can be built with industry when scientists take the time to listen to their concerns and look at how they can be resolved together.

One important element of social capital is trust and trustworthiness (Grafton, 2005). A lack of trust or understanding of the scientific process can reduce the likelihood of fishers contributing their knowledge to the scientific process. While it may seem like a chicken and egg situation, it is evident that it is important for fishers to be involved in the scientific process to build understanding and trust, and further encourage participation. The At Sea Self-Sampling Program provides a successful example of this, highlighting to fishers how they can input data directly into the scientific process whilst at the same time helping them to understand scientific sampling methods. From a potential period of crisis during Covid-19 restrictions came an opportunity for learning and development for both fishers and scientists on how industry can be more involved in national data collection. Certainly social capital was built during this process, resulting in a legacy of the ongoing at sea self-sampling programme. While placing trust in fishers to collect and provide information and data to scientists can be particularly important in building social capital, having fishers aboard scientific surveys can also be beneficial. Working alongside scientists also has been shown to help build trust and provide fishers with an understanding of why scientists operate the way they do in order to minimize potential bias.

Working alongside industry can also help in building trust from the scientists' point of view. It has been recognized that some believe that contributions of knowledge do not hold up to the quality standards or consistency that should be expected from scientific data (Steins et al., 2022). Using appropriate training, data collection methods and remuneration it is however possible for fishers to collect and contribute reliable and useful data (Neis et al., 1999; Kindt-Larsen et al., 2011; Kraan et al., 2013; Mangi et al., 2018; Bentley et al., 2019a; Steins et al., 2022). To have more confidence in the use of such data it may be beneficial for scientists to work alongside those fishers contributing their knowledge, to build working relationships and trust in the information being received. This supports the identification that building positive relationships can be one of the key steps in enabling participatory research (Mackinson et al., 2011). Progress has been made to demonstrate how FEK can be used within quantitative stock assessment processes (Neis et al., 1999; Hutchings and Ferguson, 2000) and food web modelling (Bentley et al., 2019a), which presents a large step forward for EAFM. However, there remains a lack of examples where FEK is regularly fed into stock assessments and more progress is needed to improve the integration of the fishing industry knowledge into fish stock assessment and ecosystem science (Steins et al., 2022). Trust needs to be built so that fishers

feel able to provide accurate catch information without possible negative implications and so that scientists feel confident in using FEXK in their work. Certainly opportunities to work with fishers in the field, on-board research vessels or fishing vessels provide opportunities for scientists to learn from fishers. Equally, conversing and collaborating with fishers through projects that involve interviews, focus groups and workshops provide opportunities to learn from fishers and develop a greater understanding of the industry perspectives on current and legacy issues. The two-way nature of information and knowledge exchange must be recognized when working with industry, on whatever platform and within whatever environment, to continue to build trust and fruitful working relationships.

Consideration on how best to engage with and work alongside fishers is also important. Opportunities for improving the understanding and trust required for co-creation through the engagement style and methods used should be taken seriously. If done half-heartedly, engagement can do more harm than good. It is essential that enough time is given to allow consensus to form through understanding and dialogue (Richards et al., 2007). Engagement must be thoughtful, using the tools and methods of engagement appropriate to the message and process, treat all participants fairly, use the best available scientific evidence, and present real opportunities to contribute to and influence decisions (Rowe and Frewer, 2000; Reed, 2008; Pita et al., 2010). Together these help to combat the most common frustrations associated with stakeholder fatigue (Richards et al., 2007). This paper highlights a range of ways to engage with and work alongside fisheries stakeholders, from having fora such as the IFRSP, establishing self-sampling at sea, conducting interviews and questionnaires with fishers, and developing focus groups and workshops. For those leading stakeholder events, engagement, and exercises, a basic understanding of facilitation methods, power dynamics, and social science tools can greatly help to improve the interaction. Better still, is to engage social scientists directly in the process, creating multi-disciplinary teams with more holistic knowledge and approaches that can help to improve interactions and maximize outputs. Again consideration should also be given to the point during a research project or scientific imitative as to when fishers become involved. Significant benefits can be gained from not just viewing fishers as data sources or data collectors but by developing true participatory research approaches that allow all involved to participate in the research process from the development of ideas and questions through to the design and execution (Stanley and Rice, 2017). Appropriate supports are required, however, if all involved stakeholders are to contribute to projects as equal research partners (Stanley and Rice, 2017) and additional resources may need to be found to support such efforts.

Effective communication has also been identified as being essential in order to facilitate stakeholder engagement in research and decision-making processes (Mackinson et al., 2011). A lack of trust between stakeholders, coupled with a lack of involvement in decision-making have been cited as contributing to difficulties experienced in implementing the CFP and undermining its legitimacy in the past, with improved communication outlined as a priority for the European Commission (EC) (European Commission, 2009; Pita et al., 2010; Mackinson et al., 2011). Communication has been identified as the best way to improve outcomes in social dilemmas, with face-to-face communication facilitating consistent, strong, and replicable increases in cooperation and trust (Ostrom, 1998). Our experiences show it is important to ensure fisheries stakeholders are regularly updated on and involved in scientific research throughout its lifespan, from the conception of ideas through to the delivery of results. Communicating results and outcomes from research, that has involved fishers, back to the fishing industry is essential to demonstrate the importance of fishers' contributions, but also to build social capital and ensure fishers feel valued and useful. As scientists, who regularly search for information, we may overlook how best to guide industry stakeholders to data repositories and resultant information produced by research, but this is something that can be easily overcome with a little marketing and education, and improvements in direct communication/feedback. Being realistic about expectations and changes that scientific research can deliver from the outset is also a critically important part of this communication strategy. Results from collaborating with scientists might not provide the quick solutions that some fishers may seek and this should be made clear prior to and during engagement so as not to further erode trust and social capital.

Context will always be evolving, thus it is critically important for scientists to understand the socio-ecological context in which we, the fishers, and fisheries we research operate. Scientists must acknowledge that the things we deem as important may not be as important to industry, and while we should continue to pursue collaborative science and solicit industry support, we must recognize that this process may take longer than planned when other issues and concerns move to the forefront for stakeholders (e.g. Covid-19 or Brexit). For this reason, we would urge for such considerations to be embedded in national research and policy frameworks, so that important engagement fora and the benefits of collaborative activities can continue beyond the lifespan of short-term funded directed research projects.

The many examples presented in this paper demonstrate FEK and collaborative research strengthening our scientific knowledge base. Building social capital and trust to achieve

such work collaborations has potential for significant contributions to fisheries science, providing more balanced views of issues facing fisheries and adding to important fisheries data sources. It is also possible to build from these experiences, and improved understanding from both fishers and scientists point of view to develop more truly participatory and collaborative approaches. The examples we have presented, however, represent much of the ground work that has been required to build trust between science and industry and slowly build successful working relationships between these parties.

5 Conclusion

Previous top-down management approaches, a suite of legacy and equity issues that impact upon fishers, and research that has not included stakeholders or has failed to maintain relationships with stakeholders may have eroded social capital between the fishing industry and scientific community (Grafton, 2005). The examples in this paper illustrate in stark detail the complexity of the fisheries landscape in Ireland, ranging from poor understanding, to trust issues that stem from a mistrust of the science but also from legacy issues effecting the fishing industry, to an overwhelming list of current priorities. This complexity is mirrored in many other nations and similar low levels of trust in all governing bodies in UK fisheries has also been found (Ford and Stewart, 2021). Fisheries ecology and management is complex in and of itself and inherently associated with wicked problems. It may be possible for us as scientists to work with fishers despite the legacy issues, but remaining aware of these and the pressures they have created. We must be cognizant, however, that when we attempt to regain trust and build social capital to co-manage, co-build, co-create, and collaborate with stakeholders in any form, we are asking for something; time. Very often we do not even cover the costs of participating. As such, other, more immediate factors, will always significantly impact on cooperation, even if they are nothing to do with management, science, or the questions we are asking. Given the complexity outlined herein, on the surface stakeholders really have very little reason to want to collaborate, when there is simply too much else going on. Consideration should be given to provide remuneration to fishers where possible and appropriate. This again helps to overcome issues related to the quality of FEK in relation to ensuring industry have the capacity consistently to collaborate with the scientific community and are equal parties in collaborative efforts (Steins et al., 2022) . The benefits of contributing knowledge to scientific research also need to be better considered and communicated.

Overall, while there can be numerous challenges to building trust and social capital with fishers, so that their experiential knowledge can be documented and used in fisheries science, the results from working together with industry can be significant. Despite challenges, creating opportunities to work with and alongside fishers builds the social capital and momentum to keep fostering these relationships. We have reflected on challenges unique to Irish fisheries when engaging with industry with the aim of co-producing knowledge. Many of the lessons learned and ways to progress working with the fishing industry are more widely applicable, especially within EU fisheries. Overall, however, there is no one-size-fits-all solution and time needs to be taken to understand individual fisheries and fishers, the avenues they are interested in contributing their knowledge to and the time available to them to do so.

Data availability statement

Anonymised raw data supporting the conclusions of this article will be made available upon request to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by Marine Institute Research Committee Ethics Board. The patients/participants provided their written informed consent to participate in this study.

Author contributions

JC conceptualized the original idea for the paper, conducted industry interviews and contributed to the writing and editing of the paper. DP conducted industry interviews and contributed to the development, writing and editing of the paper. MC contributed to the development, writing and editing of the paper. DR contributed to the development, writing and editing of the paper. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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