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Editorial: Co-creating knowledge with fishers: challenges and lessons for integrating fishers' knowledge contributions into marine science in well-developed scientific advisory systems

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Editorial on the Research Topic

Co-creating knowledge with fishers: challenges and lessons for integrating fishers' knowledge contributions into marine science in well-developed scientific advisory systems

This Research Topic on '*Co-creating knowledge with fishers – integrating fishers' knowledge contributions into marine science*' brings together 16 papers from researchers and fishers who have been leading science-industry research collaboration (SIRC) across regions with well-developed scientific advisory systems. In such systems, marine science is heavily dependent on both fisheries-independent and fisheries-dependent data from statutory obligations (e.g., catch and effort data). Knowledge gaps could be addressed more fully by gathering, accessing and integrating fishers' observational and experiential knowledge. Whilst efforts to this end are gaining momentum, there are few documented examples where SIRC projects are shown to be effective in scientific assessments and to inform advisory processes. Challenges associated with integrating fishers' knowledge contributions relate to both the mechanics of the scientific advisory system and opinions on governing its integrity. Deliberate contributions from industry to science, for example through SIRC, are frequently met with questions around conflict of interest, trustworthiness and reliability, hindering their integration into/with science in support of management. This is problematic in a science-policy context where use of best available

(scientific) information is prescribed or binding, but where budget declines and increasing demands for data and information to service ecosystem-based management effectively result in delegation of responsibilities (and costs) of sampling from government to industry. Our Research Topic explores and comments on the question of how to integrate knowledge contributions into well-developed scientific advisory systems. In particular, we detail studies that deal with three themes outlined in Table 1, and in the following sections, summarize their main findings. We conclude by interpreting what these findings mean for the future of marine science that has the use of best available information as its foundation.

Dilemmas in using fishers' knowledge contributions

Four papers in this Research Topic particularly speak to our first theme (Table 1). Steins et al. identify three issues that seem to be inhibiting systematic integration of voluntary industry contributions to science: (i) concerns about data quality, (ii) beliefs about limitations in usability of unique fishers' knowledge, and (iii) perceptions about the impact of industry contributions on the integrity of science. Following a review of published evidence, they conclude that, while these issues are real, they can be overcome. Moving forward requires a deliberate move towards alternative modes of knowledge production that includes the facilitation of transdisciplinary approaches to systematically collecting and analysing experiential knowledge as well as establishing clear procedures for data collection and verification. These findings are echoed in the Policy and Practice Review by Baker et al., presenting insights from a networking session of scientists and industry representatives at the International Council for the Exploration of the Sea (ICES). A key insight is that the form of collaboration and framework (mandated, voluntary, compensated or contracted) matters and influences data types and outputs. Necessary conditions for respectful and sustainable collaborative research include data quality controls. These include ensuring that data or final reports follow regulatory standards and are peer-reviewed before their use in science and management, as well as integrating fishers' knowledge in interpretation, validation, transparency, and accountability. Here, the paper by Wilson et al. offers valuable insights from practice. It examines stakeholder engagement in management procedure development in RFMOs for Atlantic bluefin tuna *(Thunnus thynnus)*, Greenland halibut *(Reinhardtius hippoglossoides)*, Atlantic mackerel *(Scomber scombrus)* and Pacific saury *(Cololabis saira)*. The four case studies differed in the amount and type of stakeholder engagement. The authors propose that the presence of formalised structures and processes are essential elements for inclusive and open engagement. Recommendations include the establishment of science-management dialogue groups, where there are key roles for stakeholder inputs and feedback during crucial stages of the process. Another example of how dilemmas in integrating fishers' knowledge play out in practice is demonstrated in the Policy and Practice Review on tackling bycatch of marine mammals and birds in the Bay of Biscay by Cazé et al. Here, complex socio-political dimensions that affect trust and lead to tensions amongst fishers, researchers, government and NGOs hinder the co-creation of knowledge to better understand fisher-species interactions for developing regulations that are adapted to local specificities. The authors use an examination of conflicts and collaboration as a tool to uncover dilemmas in bycatch mitigation policies and learn how best to overcome them. Conflicts, they argue, may serve in preparing the system for change. Disagreements can generate positive friction and become catalysts for social change, if negotiating processes are in place to allow for discussion among different narratives on sustainability and for collective learning.

TABLE 1 Themes of interest to Research Topic.

1. Dilemmas in using fishers' knowledge contributions and what it means for how the future of fisheries science is best conducted in the emerging frameworks for responsible research and innovation.
2. Experiences of how fishers' experiential knowledge from operating in a dynamic socio-ecological system has been incorporated into scientific research in support of fisheries or ecosystem management.
3. Studies that have overcome, or have been thwarted despite efforts to overcome perceived or real challenges associated with integrating fishers' knowledge contribution into current scientific advisory processes, including research integrity concerns.

Experiences of incorporating fishers' knowledge

Our second theme (Table 1) attracted eight papers. Two of these involved fishing industry-based Research Fleets, where fishers collect observational data to advance scientific understanding on fish stocks and ecosystem dynamics. Both papers show how Research Fleets can consistently collect copious amounts of data and significantly improve knowledge used to inform management, as well as strengthening partnerships between science, industry and management. Authors Heimann et al. present the example of the Black Sea Bass Research Fleet in New England to collect detailed catch data, using sampling protocols jointly developed by scientists, managers, and industry members, and streamlined to make data collection as efficient and minimally intrusive as possible. Data collected will be included in the black sea bass *(Centropristis striata)* fishery stock assessment. This collaboration is a success due to integration of stakeholder input throughout the project as well as the commitment to transparency of data collection and use among fishing industry, management, and scientific stakeholders. Similar experiences are reported in Olsen et al. where the Northeast US Shelf Research fleet has been trained and equipped with oceanographic sensors. Researchers have used the data to better understand oceanographic phenomena including marine heatwaves, shelf-break exchange processes, warm core rings, and salinity maximum intrusions onto the continental shelf. Fishers' experiential knowledge enhanced the research capacity of this project by offering a human dimension absent from uncrewed ocean observation tools. This SIRC also brought additional benefits to the fishers as they are able to use the results in real-time to help inform and guide their fishing operations.

Other ways of incorporating fishers' experiential knowledge in science are by using qualitative information from interviews, questionnaires and group discussions as an added layer to 'regular' scientific data collection and assessment or development of best practices in management. Five papers provide examples. The paper by Bliss et al. in SIRC on capelin *(Mallotus villosus)* in Newfoundland shows how interviews with fishers aided addressing key stock assessment knowledge gaps on putative deep-water spawning sites as a first step in determining the contribution of deep-water spawning to capelin recruitment. Boat-based surveys that followed resulted in knowledge on seven previously undocumented deep-water spawning sites. Researchers now use these results to build a time series for monitoring capelin spawning. As applies to other cases reported in this Research Topic, this capelin SIRC strengthened fisher-science advisor relationships. Another example where interviews played a key role is reported by Damiano et al. The paper describes the cases of Management Strategy Evaluations (MSE) of Atlantic cobia *(Rachycentron canadum)* and black seabass *(Centropristis striata)* fisheries in the Southeast US. In both cases it was not possible to conduct a "full" MSE with direct participation of fishers in the MSE process, a situation that often occurs in MSE processes and usually results in a 'desk-based' MSE. The authors explored whether semi-structured interviews with commercial and recreational fishers could elicit similar kinds of information that fishers provide during direct participation in MSE. They demonstrate this is indeed the case. Integrating information from semi-structured interviews with MSE offers a cost-effective alternative intermediate approach to fisher participation in MSE when direct participation is not possible. Authors Kelly et al. report on the on-going development of the decision-support tool FishGuider in Norway. FishGuider supports knowledge creation for research and advisory processes and also provides information to fishers to assist everyday fishing operations. Researchers used questionnaires to find out about fishers' needs in terms of information they would like to see in the tool to help inform strategic and tactical decision-making. The development process revealed important tradeoffs between comprehensiveness of the information included in the tool and user-friendliness. Also, continuous dialogue and soliciting of feedback from fishers is central to qualifying the true importance of information for decision making.

Examples of facilitating and integrating fishers' experiential knowledge using group discussions are provided in three papers. Authors Mercer et al. detail the contribution of a two-day "Northern Shortfin Squid Population Ecology and Fishery Summit" hosted by the fishing industry, towards improving stock assessment and management. Research data sets and knowledge from fishers and processors were brought together to better describe the fishery dynamics, distribution, life history, and oceanographic drivers of *Illex illecebrosus*. Post-summit collaborative work focused on jointly developing custom standardized catch per unit of effort indices to provide indicators of population trends, now used in the stock assessment. The authors suggest that large-group summits are effective for developing initial relationships and trust between science and industry collaborators and identifying research priorities, while semi-structured conversations with individual industry members facilitate understanding of specific factors that influence fishery dynamics and identification of potential covariates for catch rate standardizations. Such conversations are also effective for reviewing research results and identifying future work areas. The paper by Murua et al. reports similar benefits of knowledge exchange workshops and co-developed research activities with fishers from the principal tropical tuna purse seine fleets of 23 countries. Fishers' experiential knowledge was sought to reduce ecological impacts associated with the use of fish aggregating devices (FADs), by empowering and equipping skippers and crew with the means to address bycatch in their fisheries. The programme had a strong communication focus and resulted in innovative, co-constructed solutions, better stewardship and increased trust of scientists. It has stimulated unprecedented large-scale science-industry research projects across oceans, such as multi-fleet biodegradable FAD trials, widespread use of non-entangling FADs, and adoption of best practices for the safe handling and release of vulnerable bycatch. The Policy Brief by Baker et al. outlines opportunities and implications for improving marine science and fisheries management through SIRC, leveraging insights of more than a hundred researchers, managers, industry representatives and fishers participating in the Lowell Wakefield Fisheries Symposium on cooperative research and strategies for integrating industry perspectives and insights in fisheries science. To be effective, these types of collaborations require understanding the strengths, perspectives, interests, structures, and sensitivities of participating groups, as well as identifying methodologies and study designs necessary to ensure robust scientific results. Key insights were that initial success is often achieved through finding common ground and staying simple, while long-term success is often achieved by maintaining momentum, carefully examining processes, and repeating what works. Continued collaboration means constantly refreshing and revisiting aims and objectives, and constantly refining the approach and addressing challenges and limitations to collaboration. Best practices for SIRC include collaborative, robust, relevant, cost-effective and timely initiatives that involve dedicated and engaged partners.

Overcoming challenges in using fishers' knowledge

Our third theme (Table 1) is central to four papers. Two papers are about dealing with challenges in setting up research fleets for improving stock assessment quality. Jones et al. discuss the lessons learned from the Northeast US Study Fleet programme, where groundfish fishers collect high-resolution catch, effort, and environmental data to address shortfalls in fisheries-dependent data collection. Like other authors in this Research Topic, they experienced that interactions with industry emerging from the collection and application of these data contribute to increasing mutual understanding and trust. Sustaining the interest on both sides of the collaboration needed for consistent time-series is, however, a challenge. This is also true for addressing equity issues and potential bias associated with working with a select group of fishers. Also there are challenges in dealing with data for science and

data for regulatory purposes. The authors stress the importance of ongoing communication with captains and involving boundary spanners. They recommend developing detailed roadmaps for each data collection to keep participants engaged as collaborators, targeting specific fisheries to keep resources from being stretched too thin, and partnering with data end-users early in the process. The paper by Mackinson et al. reports on the processes and challenges associated with the development of the Scottish Pelagic Industry-Science Data Collection Programme into a routine and consistent voluntary sampling regime of sufficient quality, which is now the main source of biological data on pelagic fish catches in Scotland. One challenge identified was the perceived reluctance from the national administration, driven by concerns over data quality, data continuity and reputational concerns. These were overcome by setting up a collaborative process from the beginning and starting with a pilot process that enabled a step-wise approach, followed by the development of a Memorandum of Understanding to ensure data collection flows from the industry. Transparency, documentation, and communication were key in dealing with the issue of reputational concerns. A second challenge was balancing the pace of progress with expectation: too slow for the industry, too fast for the national administration. Monthly meetings and setting realistic time scales for individual tasks were key to managing this. This paper also identifies core design principles of SIRC that are also transferable to other sectors. These include the importance of quality assurance and a good communication structure.

The two other papers on overcoming challenges are examples of where management or political related concerns, legacy and trust issues entangle with scientific co-creation processes. The paper by Schram et al. is about concerns raised by small-scale fishers and NGOs over the possible adverse effects on marine organisms caused by the electrical stimulation of flatfish pulse trawling in the North Sea. These fishers were involved in the design and implementation of a fishing experiment to investigate their concerns. This, as well as engaging them in discussion of the results was important in increasing the saliency and credibility of the results. It also revealed the intricate relation between perceived scientific knowledge gaps and political or management related concerns. Authors Calderwood et al. take a narrative approach to collaboration with Irish fishers to co-create knowledge. Drawing on case studies, they reflect how data from industry can best be used and integrated into scientific processes. Key barriers include misunderstandings regarding the roles of scientists and the scientific process, a lack of transparency, a lack of trust, legacy issues from previous management approaches and research with poor stakeholder engagement, and impacts of Brexit. Remaining aware of these issues and the pressures they have created is critical to effectively co-create knowledge and common understanding. Equally important are building trust and active communication. The authors emphasize that efforts to build social capital for co-managing, co-creating, and collaborating with fishers includes an inherent request for their time, whilst research often does not even cover the costs of participating. This issue should be addressed. They also acknowledge that there is no one-size-fits- all solution for building social capital with fishers. Time is needed to understand individual fisheries and fishers, their interest in contributing their knowledge, and time available to do so.

Conclusion

Our Research Topic brought together a wealth of information on dilemmas, experiences, challenges and opportunities associated with integrating fishers' knowledge contributions into marine science. We deliberately focused on regions with well-developed scientific advisory systems as this is where issues about stakeholder engagement and knowledge co-creation are matters of debate rather than necessity. Responsible research and innovation frameworks demand use of 'best available information', and in relation to fisheries, some information can only come from fishers.

The collection of papers in this Research Topic substantiates that use of 'best available information' is confronted with legitimate concerns regarding perceived risks to the credibility of scientific advice, particularly when science evidence is applied to management. Such concerns can be overcome by developing transparent quality assurance systems in a collective effort between scientists, fishing industry, managers and other relevant stakeholders. Also, objective evaluation of the performance of the information for its intended purpose is required. This calls for adaptations to current fisheries governance frameworks and a new culture of cooperation.

A common thread in all papers is the important contribution SIRC provides to establishing a relationship of mutual trust, which is essential to establishing salient, credible and legitimate science for advice.

From the collective experience documented, we extract ten commonly applicable guiding principles for integrating contributions from SIRC into conventional marine sciences: (1) identify where there is both opportunity and utility in information that fulfils a need expressed by industry or science; (2) take fishers' concerns seriously even if they do not seem at first to make 'scientific sense'; (3) always be open and honest with others and address 'elephants in the room', including equity issues; (4) be aware that fishers' participation is linked to their sense of ownership; (5) recognize that fishers' time for participation is (usually) not paid for, unlike that of scientists, and discuss ways of acknowledging or rewarding them even if it cannot be financially; (6) create effective and regular feedback mechanisms between scientists and the skippers and crew involved; (7) involve end-users of the data from the outset; (8) in case of data collection by fishers, (jointly) establish transparent quality assurance processes; (9) involve social scientists when using qualitative collaborative research methods; and (10) constructively engage, challenge and support necessary developments in national and international institutional processes that determine whether data from industry programmes or other fishers' knowledge contributions have the chance to be applied in stock assessments or other science for advice.

Author contributions

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Author Kate Brooks was employed by company KAL Analysis.

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