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The compatibility of fishers and scientific surveys: increasing legitimacy without jeopardizing credibility

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For a long time, fishery-independent surveys were only carried out by scientists. On-going criticism by Dutch fishers on the North Sea beam trawl survey prompted scientists to invite fishers on board. Since 2007, fishers have annually joined the survey as observers. Observing all steps in the survey like rigging the gear, the selection of fishing locations, catch sorting, and data registration enables fishers to provide feedback based on their experience instead of preconceptions. Where possible, their suggestions for improvements are incorporated. Since fishers joined, the nature of discussions about the survey has changed to being constructive. The fishing industry's trust in survey methods, results, and the scientific crew increased. Scientists gained a better understanding of the importance of the survey for fishers' livelihoods. The observers also inspired continuous scientific scrutiny of the survey, its setup, and objectives. We describe the process of incorporating fishers in a fishery-independent survey, its benefits, and challenges. We show how perceptions about the survey changed. Allowing stakeholders behind the scenes of a survey and taking their expertise into account contributes to a more reciprocal relation in the co-production of knowledge through collaborative research and increases legitimacy. We propose guidelines for involving stakeholders without compromising the survey's and professional credibility.

Keywords: beam trawl, collaborative research, co-production of knowledge, credibility, fish stock surveys, fisher knowledge research, fisheries, fishery-independent data, guidelines for collaboration, stakeholder involvement

Introduction

Fishery-independent surveys are used in fish stock assessment models next to information from commercial catches. Scientists design surveys to catch fish in a standardized manner, across the full geographic distribution of the survey's target species. As estimates of absolute numbers of fish are often out of reach, there is a strong focus on relative trends. Fishers, on the other hand, go out fishing to catch as much fish as they are allowed to. They follow the fish and skip areas without fish, as "no fish" means "no income." For fishers, the absolute numbers, or rather kilos, are the main interest. Scientific surveys and commercial catches are both important sources of information to understand the availability and development of fish resources (Mackinson and Van der Kooij, 2006). However, fishers often question the reliability of surveys, for example, when their own observations are at odds with scientific findings or with their ideas on how data should be collected (Degnbol, 2003; Cotter, 2004; ICES, 2005; Mackinson and Van der Kooij, 2006; DeCelles *et al.*, 2012; Johnson and McCay, 2012; Pearson *et al.*, 2020; Raicevich *et al.*, 2020). Are people with two very different perspectives on "successful fishing" able to have shared experiences on a vessel, and to accept and understand each other?

In the Netherlands, we have been taking fishers as observers on board on one of our fishery-independent surveys, the beam trawl survey (BTS) on the research vessel "Tridens" (see Box 1) since 2007. Demersal fishers felt this important survey was a black box (*cf.* Johnson and McCay, 2012), and we intended to open it. The timing overlapped with the last year of the so-called "F-project" (2002–2007). In this project, fishers, researchers, and managers worked closely together to improve the quality and transparency

of the fisheries advice for the management of North Sea sole (*Solea solea*) and plaice (*Pleuronectes platessa*) (Quirijns *et al.*, 2007). As a result, collaboration between scientists and the Dutch fishing industry has thrived (Steins *et al.*, 2020). Partnerships between scientists and industry have also been developed in other countries across the globe, with (combined) objectives of cost-effective comprehensive data collection, improving mutual relationships and trust, capacity-building, co-production of knowledge, providing alternative sources of income for fishers, and strengthening the societal relevance of research (Kaplan and McCay, 2004; Johnson and Van Densen, 2007; Verweij *et al.*, 2010; Mackinson *et al.*, 2011; Johnson and McCay, 2012; Stephenson *et al.*, 2016; Mangi *et al.*, 2018; Bentley *et al.*, 2019; Holm *et al.*, 2020; Österblom *et al.*, 2020; Steins *et al.*, 2020). This co-production of knowledge through science-industry research collaboration is part of an emerging focus on "post-normal science" (Funtowicz and Ravetz, 1993) in marine research, recognizing that the socio-ecological nature of marine systems (Berkes and Folke, 2000) is associated with "wicked problems" (Jentoft and Chuenpagdee, 2009). This implies that start-to-end stakeholder involvement, including in science in support of management, is required (Funtowicz and Ravetz, 1993; Röckmann *et al.*, 2015; Verweij *et al.*, 2010; Bentley *et al.*, 2019; Steins *et al.*, 2020).

The scientific literature on science-industry research collaboration (SIRC) has a strong focus on the role of fishers in strengthening our scientific knowledge base. This role is defined either by using fishing vessels as a platform to aid in the collection of data or by using fishers' experiential knowledge in mapping or interpreting observed changes in fisheries or ecosystems (Stephenson *et al.*, 2016). In this context, SIRC projects often have a unidirectional character: whilst both fishers and scientists acknowledge the mutual advantages of working together, the flow of information tends to go from fishers to scientists; examples include scientists joining fishing vessels or fishers carrying out sampling for scientific purposes. As a result, fishers' insight fishers into the scientific framework of data collection is generally related to fishery-dependent information. Fishers' access to fishery-independent data collection, such as surveys on research vessels, is limited, and sometimes tightly controlled (Johnson and McCay, 2012). Our experiences with fisher observers on board of a survey on a research vessel including open access to all areas relevant for the survey enable us to explore if and how a more reciprocal relation in data collection adds value to SIRC. From informal communications with European colleagues, we understand this is quite a unique situation; responses by colleagues vary from positive to being confused. One shared initial question is: "how do you make sure they [the fishers] don't influence your work?", the implicit question being how do we ensure the scientific quality of the survey results. Another question is: "what is in it for you?."

In this article, we describe our and the fishers' experiences and how to take comments from fishers into account. We show how this increases the legitimacy of a fishery-independent survey without jeopardizing its credibility. Giving insight in the data collection helps increasing confidence in methods and results, and sharing experiences lead to better understanding of the work carried out. Based on over 10 years' experience, we conclude with a set of specific guidelines for taking fishers as observers on surveys.

Methodology

Each year following the BTS (Box 1), the Dutch fishing newspaper (*Visserijnieuws*) interviews the fishers who joined as observers. We analysed all interviews published between 2007 and 2019 (Table 1, column 4). In addition, we reviewed personal notes some fishers shared with us, and the minutes of BTS evaluation meetings. Our analysis focused on the experiences and perceptions of fishers about the BTS and possible changes. We identified nine themes (in alphabetical order): (i) catch success (survey vs. commercial); (ii) collaboration; (iii) fishing gear; (iv) general experience; (v) organization and quality of the work; (vi) planning; (vii) survey coverage; and (viii) towing speed; and (ix) weather. All comments were allocated to these themes. For each comment, we assessed whether the comment was positive or negative feedback (see Changing perceptions section, Table 3).

In addition, we analysed general articles related to the BTS in *Visserijnieuws*, the BTS weblog, and minutes and reports of the F-project and other SIRC project meetings in relation to fish stock surveys. We held informal interviews with the scientist in charge on her experiences and observations. During the BTS in 2019, we carried out two in-depth interviews with fishers, and short interviews with the three scientific crew and a volunteer. In addition, we interviewed one of the industry representatives after the survey. The analysis of the time series of interviews in *Visserijnieuws* combined with these additional data sources gave a qualitative representative picture (Dinklo, 2006) of the possible

Box 1. The Dutch beam trawl survey (BTS)

The Dutch beam trawl survey (BTS; ICES, 2019) was set-up to create fishery-independent indices for plaice and sole in the North Sea for the stock assessments carried out by the International Council for the Exploration of the Sea (ICES). The Dutch fisheries institute (currently: Wageningen Marine Research) started the survey in 1985 on Research Vessel (RV) "Isis." The survey targets plaice and sole, both important species for Dutch demersal fisheries. In 1996, The Netherlands expanded the beam trawl survey in the Central North Sea using RV "Tridens." Since 2017, all stations are fished by RV "Tridens." The BTS is annually carried out in (July–)August–September in a standardized way, described in the institute's protocols and in the international beam trawl survey manual (ICES, 2019).

Although the BTS was originally set-up for the collection of fishery-independent data on plaice and sole, all species caught have been registered since the beginning of the survey. Lengths of all fish and crustacean species of commercial interest are measured. Numbers and/or weights are taken from the epibenthos. Biological information like weight, sex, and age is collected for a selection of flatfish species. From 2011, also composition of litter in the catch is registered (ICES, 2018, Annex 9c). The resulting survey information is currently used for stock assessments of multiple flatfish and elasmobranch species, for ecosystem studies and as data source for the European Marine Strategy Framework Directive. The ICES stock assessments for plaice and sole are based on the age-structured AAP model using survey indices from the BTS and a number of other fisheries-independent surveys and data from commercial fisheries (catch, ages, and length frequencies from port and on board sampling) (ICES, 2020a, b).

Table 1. Overview of interviews with Dutch BTS fisher observers and articles in Visserijnieuws (2007–2019).

Year	Number of fisher observers on BTS[a]	Number of survey weeks with fisher observers[a]	Number of articles with BTS fisher observer interviews[b]	Number of general articles related to BTS[b]
2007	4	5	4	2
2008	4	4	5	3
2009	4	4	2	5
2010	4	5	3	3
2011	3	4	2	2
2012	4	4	2	2
2013	4	4	2	2
2014	4	4	1	2
2015[c]	1	1	0	2
2016	4	4	1	0
2017	4	5	2	1
2018[d]	7	7	1	0
2019	7	7	1	2

Sources: [a]Internal WMR BTS reports and [b]www.visserijnieuws.nl. Total number of unique fishers 2007–2019: 29.
[c]Due to a refit of RV "Tridens," no fisher observers could join due to safety regulations. Comments on the survey in this year refer to RV "Isis."
[d]From 2018 the BTS is fully carried out by RV "Tridens," allowing for observers throughout the entire survey.

opinions and attitudes towards (participating in) fishery-independent surveys by demersal fisher observers. It enabled us to identify changes in perceptions, and also to relate changed perceptions to a changed landscape of cooperation.

When quoting fishers, we use their full name when citations refer to published articles in *Visserijnieuws*, as these comments are publicly accessible. We only anonymize quotes from formal interviews.

Taking fishers "on board"

Opening the black box

At the turn of the millennium, the relationship between the North Sea fishing industry and the Dutch fisheries institute was at an all-time low. The industry perceived that fishing mortality for plaice and sole was overestimated and stock assessments could not be accurate (Steins *et al.*, 2020). The industry, institute, and managers felt that communication and mutual understanding had to be improved. A dedicated SIRC (F-project) was set-up, focusing on improved quality and transparency of the quota advice (Quirijns *et al.*, 2007). In the period 2002–2007, a reference fleet of beam trawlers assisted in the development of a Landings per Unit of Effort (LPUE) series. Simultaneously, a lot of effort was put in capacity-building within the industry (fishers and representatives), focusing on how stock assessments are done and how the process from data collection to the allocation of quota works (Quirijns *et al.*, 2007; Steins *et al.*, 2020). In the final year of the F-project, participants concluded that understanding about the assessment and advisory process had increased and communications between science and industry had improved (Quirijns *et al.*, 2007).

However, in one of the F-project meetings, the industry concluded that the discussion about the accuracy of the plaice stock assessment was still open ended. The LPUE series were not being used by ICES, and the in BTS survey (Box 1) some specific plaice fishing grounds where fishers were having excellent catches, were left out. Fisher and representative Wim de Boer (UK104) expressed his frustration: "Science maintains its own course. [. . .] For example, the fish stock surveys are way below par. On the one hand, because the crew on Tridens all have a pelagic background. On the other hand, because crucial fishing grounds are not surveyed. And what does one haul of 30 minutes per year in a 30 nautical mile square with a wrong net say anyway?" (Visserijnieuws, 6 March 2007). In a subsequent meeting, the survey programme leader was invited to explain the setup of the BTS and the other two surveys used in the plaice and sole stock assessments (Sole Net Survey and Demersal Fish Survey). Again, the fishers criticized the fishing gear and the quality of work on board the survey vessels and questioned the survey results. They expressed concerns that for them, the survey was a black box (*cf.* Johnson and McCay, 2012). During the meeting, the scientists decided to invite fishers on board as observers, to open that box. The fisheries representatives welcomed the invitation and looked for volunteers to join the beam trawl survey for one or two weeks (Productschap Vis, 2007). The fisheries associations took care of travel expenses and a small financial compensation for the fishers.

Observers were only allowed to join RV "Tridens," as room on the second vessel, RV "Isis," is limited. Only in the first year (2007) and in 2015, exceptions were made for one fisher who joined RV "Isis" for 1 week. In the latter year, RV "Tridens" was undergoing a refit and access was limited due to safety regulations. In 2010, a fisher boarded RV "Isis" for a 1-day test trip prior to the official BTS, to see how the gear was installed by the crew.

Rules of the game

From the outset, the institute and the industry agreed on a set of rules in relation to the number of observers, responsibilities on board and communication. This set of rules is still in place today. Three conditions apply for taking observers on board during the BTS. First, the observer is an observer and should not influence the survey by making decisions or carrying out survey-related activities without scientific supervision. Second, observership is open to stakeholders from the fishing industry as well as other interested parties. Last, only one observer at a time can join the survey. Having more than one fisher on board, or even stakeholders from two different perspectives, increases the risk of discussions that distract attention from the objective of providing insight in the survey and the work on board. Other stakeholders than fishers (e.g. environmental NGOs) have been contacted, but none has attended the survey up till now.

Prior to the survey, (fisher) observers receive the cruise plan containing all the information on the survey like the objectives and fishing and sampling methodology. During the survey, they are allowed to see everything that is being done: they are allowed on the bridge; can have a look at the gear; watch or help sorting the catch; watch the collection of otoliths, benthos, marine litter, and other activities; and have a look at the data entry. The only conditions are that (i) observers follow the survey protocol when helping the scientists and (ii) they accept that decision-making is the exclusive responsibility of the scientists in collaboration with the crew of the research vessel. This means that fishers are not allowed to decide on fishing positions, modify the gear to their own insight and decide on catch sorting on their own behalf.

The final decision on fishing position is taken by the captain based on the criteria in the protocol and local situation. Gear maintenance based on the gear descriptions is the responsibility of the deck crew. Catch sorting by others than the scientific crew (volunteers, observer, and crew members) is always supervised by one of the scientists.

Communication about the survey

After each survey week, the fisher observers and the responsible cruise leader are interviewed by the fishing newspaper *Visserijnieuws* to inform the wider fishing community about their experiences. Since 2010, most interviews include a link to the weblog on the survey (beamtrawlsurvey.blogspot.com). The blog was initiated by the BTS project leader to inform a wider audience about the work carried out at sea. The blog, combined with the presence of a fisher on board, allows for sharing answers on specific questions raised by the fisher on board, to a wider audience. For example, when a fisher observer asked what happens to the data after the survey, we wrote a specific blog on plaice and how the data are being used in the stock assessment.

Upon completion of the survey, the observers receive the BTS survey report, providing an overview of fishing locations, time series for key species, number of samples, and a narrative of the cruise. In 2007, 2008, and 2009, an evaluation meeting with scientists and all fishers who joined the survey was organized (see next section). In 2009, 2010, and 2013, a dedicated letter was attached to the survey report describing the survey results. In 2011 and 2012, and from 2014, the fisher observers only received the regular survey report. The industry had indicated that an evaluation meeting was no longer necessary. This reduction in explicit evaluative communication was primarily a result of increased trust of the fishing industry in the quality of the work done on board, by the vessels' crew as well as the scientists, and the consistency of the work over the years.

Dealing with observer comments

After the survey

Following the survey in 2007, we collected comments from the fisher observers and discussed these in a meeting with the fishers, their representatives, scientists, and the government. In contrast to previous years, when discussions about surveys were hampered by emotional responses (*cf.* Johnson, 2009) and focused on the differences between fishers' and scientists' approaches, discussions now remained technical. Discussions now focused on a common goal: how to let the survey be a reliable source of information? This allowed for open dialogues on the possibilities to take suggestions from fishers into account without compromising the credibility of the survey (*cf.* Johnson and McCay, 2012). It is likely that previous emotional responses by the industry are related to the black box the survey had been up to then, and the scientists' inability to bring their approach across due to the lack of common ground.

We divided comments in three categories: (i) suggestions directly taken into account as those did not need additional resources or caused major effect on the survey results for the end user; (ii) suggestions that needed additional resources to be taken into consideration; and (iii) suggestions not taken into account as those would lead to fundamental changes in the survey protocol and so the time series of the survey. Table 2 summarizes the fishers' feedback and the measures taken. Whilst most feedback and measures speak for themselves, some require further elaboration. For example in the first category, fishers suggested that gear checking should be done in collaboration with the fishers under responsibility of the scientists (Table 2: 1.e). The fishers understood the criteria for standardization, but they would also like to be able to keep track of the survey net quality (cf. DeCelles *et al.*, 2012; Johnson and McCay, 2012). To allow for that, collaborative gear checking started. Fishing company *Rederij L. de Boer and Zonen* offered a location where the nets could be hung out in preparation of the survey. Wim de Boer (UK104), nationally well-respected for his net-making and fishing skills, checked the

Table 2. Overview of suggestions made by fishers, divided in three categories, and measures taken.

Category of feedback from fishers	Feedback	Measure
(1) Direct changes based on the feedback of fishers	a. Stop fishing when wind force is above than 7 Bft	a. Added to all survey protocols
	b. Stop fishing when the wave height is more than 2 m (especially in areas less than 50 m deep)	b. Register wave height in addition wind direction and wind speed. Added to all survey protocols
	c. Avoid fishing in the Dogger Bank with north-westerly winds	c. Added to all survey protocols
	d. Include three extra sampling stations for the RV Isis	d. Added by shifting stations
	e. Checking the gear should be done in collaboration with fishers	e. Added to beam trawl survey protocol that gears are checked annually by research institute's technician, representative of ship's crew and a fisher
(2) Changes that would require additional resources	f. Sample more locations (especially at the Doggerbank)	f. No extra budget available to make this change.
(3) Feedback that cannot be accommodated for in the survey	g. Use different gear	g. Recommendation to set-up industry survey
	h. Increase towing speed	i. Recommendation to set-up Industry survey
	f. Change fishing area	g. Recommendation to set-up industry survey

Table 3. Overview of developments in number and tone of fishers' comments in *Visserijnieuws* interviews (2007–2019), organized in nine themes: catch rates (survey vs. commercial); collaboration; fishing gear; general experience; organization and quality of the work; planning; survey coverage; towing speed; weather.

No.	Theme	Tone	2007–2008	2009–2010	2011–2015	2016–2019	Qualitative interpretation of temporal pattern in comments
1.	Catch rate	−	1	0	1	0	Possibly related to the industry survey[a]
2.	Collaboration	+	7	2	8	8	All periods
3.a	Fishing gear	−	10	1	4	3	All periods
3.b	Fishing gear	+	1	1	2	5	All periods
4	General experience	+	2	2	9	10	All periods
5	Organisation and quality of the work	+	2	3	4	6	All periods
6	Planning	−	3	0	0	0	Only 2007–2008
7.a	Survey coverage	−	10	2	0	1	No pattern
7.b	Survey coverage	+	2	0	0	0	Only 2007–2008
8	Towing speed	−	2	0	0	0	Only 2007–2008
9.a	Weather	−	1	1	1	0	No pattern
9.b	Weather	+	2	1	0	0	Before start of industry survey[a]

Tone: −, negative feedback; +, positive feedback.
[a]Industry survey: pilot development 2009–2010; full survey 2011–2015.

nets for damage following each survey. He and his sons also cooperated with institute's gear technician and RV "Tridens" crew in rigging the nets on RV "Tridens." Since then, the three involved parties feel jointly responsible for the quality of the survey nets. From the experience of collaborative gear checks, in 2008 Wim de Boer proposed a cosmetic change to the BTS net to improve acceptance of the net by the fleet (OSW, 2009). Neither he nor the ship's crew and the institute's gear technician expected any change in catchability by this modification. In 2009, only the portside net on RV "Tridens" was modified. Its effect on the plaice catch was investigated by measuring all plaice from the portside net additionally to the standard measurements of the starboard net. The modification had no significant effect (De Boois, 2011), so in 2010 the starboard net for RV "Tridens" was also adapted. In 2010, the portside net on board RV "Isis" was changed and the effect on sole was investigated, showing no significant effect either (De Boois, 2011). This resulted in the modification of the starboard net of RV "Isis" prior to the 2011 survey. These actions partly addressed concern 3.g in Table 2.

Observer feedback also resulted in a slight extension of the survey area to account for changes in flatfish distribution (Table 2: 1.d). This measure was only possible due to the stratification of the survey, enabling a slightly lower effort in other areas and freeing up time for the additional hauls in the new area.

Change of gear, towing speed and fishing area (Table 2: 3.g–i) were put in the third category. These comments mainly arose from concerns that the towing speed, gear, and area were not fit for purpose, especially with respect to larger flatfish. All parties understood these observations from a fisher's perspective but also realized that measures could not be implemented in the current survey as this would impact its catch efficiency and hence the time series. From 2008 onwards, fishers and scientists discussed possibilities to further investigate these concerns, resulting in an industry survey (see Changing perceptions section). To inform the fishing fleet of the feedback by the observers and actions taken, we published an article in *Visserijnieuws* prior to the 2008 BTS (Visserijnieuws, 2008).

On board

Taking stakeholders on board means that questions and comments on the work done will arise. Most fishers, when they arrive on board the research vessel, immediately want to start discussing the survey. In the first years that indeed happened, leading to discussions based on preconceptions from both sides rather than on shared experiences. After some time, we realized that discussions are more effective and fruitful after the first haul has been carried out. By doing so, everyone can relate to a shared experience, and discussions become more focused. Furthermore, when everyone knows the "how" it becomes easier to discuss "why questions" (*cf.* Johnson, 2009).

Of all the comments by individual fisher observers, two stand out (*cf.* Verweij *et al.*, 2010). These were put forward by many of them, independently of each other, and recurred over the years. The first is "We already knew in January that there is a lot of plaice in the North Sea." In response, we explain that we hope to see a similar pattern, but that the survey is set-up to sample once a year, in August/September. We also explain that the survey is one of several data sources for the stock assessment; and that we also use commercial catch data. For the survey information it is most important to always sample in a standardized manner, including the seasonality. We then clarify that we are even more confident in the results when they are in line with the fishers' information. The second is the question whether or not we observe more or less plaice than the year before, in specific areas. We explain that it is only possible to have any insight in patterns based on an complete survey, as fish distribution might vary by year, and so, we only are able to compare the data after the survey has finished.

Already in 2007, the fishers opted for having direct comparisons between research vessel catches and catches on a commercial vessel (*cf.* Cotter, 2004; DeCelles *et al.*, 2012; Johnson and McCay, 2012). Wim de Boer (UK104), who wrote a logbook of this observer trip: "I would have liked to do another haul with him [the vessel L510, fishing in the neighbourhood] to see the difference in catches between a normal beam trawler and Tridens, but I was told that I wouldn't get permission from the cruise leader" (W.

De Boer, unpublished data). The following week his nephew Louwe de Boer (PW457) joined RV "Tridens." He spotted the beam trawler FD253, and jointly with her skipper and the BTS cruise leader made arrangements for RV "Tridens" to do one haul together, whereby the beam trawler followed the fishing trail of RV "Tridens" for the same haul duration, at her own regular towing speed. One of the scientists was dropped off on board the FD253 to measure the plaice catch. Corrected for speed and gear, the difference in numbers of plaice between RV "Tridens" and FD253 was a factor 4. The maximum length of plaice in the catch was equal for both vessels. The fisher concluded: "So this is plaice that is actually there, but the biologists do not see. This was at 40 m depth. If you go to dryer grounds on the Dogger [Bank], where the seabed is even harder, the difference will be even bigger." (Louwe de Boer, PW457, Visserijnieuws, 7 September 2007). The fishers appreciated the flexibility of the cruise leader to do a spontaneous catch comparison in response to comments on board, but to them the differences in catch per haul stressed the urgency of setting up an industry survey.

Industry survey

In 2009–2010, ongoing discussions on how to deal with feedback in relation to the catch rate of the BTS (fishing gear, towing speed, survey coverage, Table 2: 3 g–i) resulted in a pilot project into an industry survey for plaice and sole, where fishers would co-decide on the gear used, towing speed and survey area (Quirijns *et al.*, 2010; Quirijns and Miller, 2011). The industry survey was carried out from 2011 to 2015 (Rasenberg *et al.*, 2012; Rasenberg and Machiels, 2013; Rasenberg *et al.*, 2014; Van der Reijden *et al.*, 2014; Van der Reijden *et al.*, 2015). After 5 years, the final comparison of catch rates for plaice and sole from the industry survey time series with those of the BTS showed that trends observed were fairly similar (Van der Reijden *et al.*, 2016). The fishing industry then decided to cease the industry survey: "The industry survey for plaice and sole did not provide added value. The comparison [between industry survey and BTS catch rates] and the observations from the fisher observers [on the BTS], show that the BTS provides good quality [data]" (industry representative).

Changing perceptions

Recurring themes and changing tone

By opening the survey black box we hoped that fishers' understanding of the role of surveys in stock assessment and their consequent set-up would increase. Analysis of the fisher observer interviews in *Visserijnieuws* (Table 1) and other articles and meeting reports in relation to fish stock surveys shows that discussion topics and perceptions changed over time. Some topics were only mentioned in the first years; some were recurring but often the tone of the feedback changed, and became more substantiated by factual observations. The change in tone generally happened when fishers had been on the survey for a second year. The change is probably also related to the way their most important negative feedback (survey coverage, catch rates of the survey compared to commercial vessels and the survey gear) was addressed by the scientists (see Table 2). We identified four time periods in relation to changing perceptions: 2007–2008, 2009–2010, 2011–2015, and 2016 onwards. These coincide with our handling of the fishers' input to the survey and the development of the industry survey. Table 3 summarizes the analysis.

Overall experiences

Without exception and throughout the years, the general experience of the fisher observers has been positive. They appreciate the possibility to be present on board during the surveys (Table 3: 4) and the collaboration (Table 3: 2). They value the organization and quality of the work done on board, especially the work ethos of the crew and scientists (Table 3: 5). Eleven comments highlighted that scientists work thoroughly and precise. Nine fishers stressed that they "have learned a lot". Illustrative is the following quote by Arie Koffeman (UK184): "I am 300 percent positive about what I have seen and experienced. We have to acknowledge that those on board of the scientific research vessels don't just do something. They work very precise and are thorough and work with craftsmanship. The cooperation and explanations given were sublime. I don't want to hear any negative comments." (Visserijnieuws, 31 August 2007).

Fishing gear

The suitability of the BTS fishing gear is a recurring point of feedback throughout the time series of observer interviews in *Visserijnieuws* (Table 3: 3a). This is predictable as the gear and a good net is an essential element of a fisher's craft (cf. Cotter, 2004; Stauffer, 2004; ICES, 2005; DeCelles *et al.*, 2012; Johnson and McCay, 2012). The suitability of the survey gear is questioned either directly or indirectly. Direct comments concern the light weight of the survey gear compared to a commercial beam trawl. Indirect comments relate to the gear's limitations in terms of catch success (Table 3: 1), towing speed (Table 3: 8) and weather effects on the catches (Table 3: 9a). Illustrative are quotes like. "With a towing speed of 4 miles an hour and two gears of 8 meter width, once a year 0.0016 percent of an ICES quadrant is sampled. Can one speak of a reliable stock survey?" (Loed Zijlstra, HD36, Visserijnieuws, 21 September 2007). "We did a haul at 6"30 at "57 and had no more than 10 plaice in the catch. Five miles to the west the Danish trawler L510 (former LT1005) was fishing. I spoke to the skipper and he did hauls with 18 up to 23 baskets of plaice in the same quadrant. A great example, as what should be the focus here? The haul of the scientist who barely sees plaice or the haul of the fisher who manages to get a lot of plaice out of the sea?" (Wim de Boer, UK104, Visserijnieuws, 31 August 2007). Similar comments have been reported in collaborative survey projects in the United States (Johnson and McCay, 2012).

While fishers still regard the survey gear as unsuitable for catching a lot of plaice or for certain seafloors, their perception about the survey as a whole seems to change over time (Table 3: 3a, b). In 2012, a first visible change appeared, as a negative comment was immediately followed by a positive: "In our fishing practice we would of course do it all differently, but I understand that for scientific research standardisation is important." (Hendrik Romkes, BCK40, Visserijnieuws, 8 September 2012). Similar comments from fishers were reported in *Visserijnieuws* in 2017 and 2018, and mentioned in the in-depth interviews with two fishers in 2019. Fishers who joined now seem to understand the need for standardization of the gear, even though it catches less fish than they would like. They also understand that they are not allowed to change the gear setup during the survey to optimize catch efficiency on a local basis, even if from their perspective this setup is not the best choice (*cf.* Cotter, 2004; Johnson and McCay, 2012). Scientists in turn, have learned to express that

they fully understand this ambiguous feeling instead of merely defending the choice of gear.

The shift towards more positive comments on the themes fishing gear (Table 3: 3b) and weather (Table 3: 9b) can be directly related to the follow-up actions from the evaluation meetings in 2007 and 2008 (Table 2: 1a, b, c, e). Since 2008, a fisher is involved in the gear rigging prior to the survey, which increased confidence in the survey. Changes in the survey nets, upon suggestion of this fisher, albeit cosmetic, were also appreciated and reported in the fishing newspaper (Visserijnieuws, 2010). The relationship between the cooperation around the survey gear and the survey results was also brought up in the formal interviews. A fisher observer: "I heard it was a big improvement that [fishing company] Rederij de Boer became involved. Before that time [prior to 2007] the nets could not be properly stored so they shrank and the next year they were just taken of the shelf and used again. Well, we fishers know that the net doesn't fish properly if you do it like that because the proportions have changed." An industry representative: "When we heard that this year [2020] we couldn't have observers on board because of the COVID-19 restrictions, we thought it was a shame because we want to give the fishers the experience and show them why the survey is done in this way. But in the end to us, the most important thing is the gear and we remain involved in that part. That's where our confidence in the survey depends on. We know you [the scientists] are doing a good job on board."

The changing tone in relation to fishing gear and cessation of comments on catch success also coincides with the industry survey. The differences in BTS catch success compared to a commercial vessel are still questioned when the industry survey is carried out, but cease upon its completion (Table 3: 1). The post-industry survey period also shows an increase in the number of positive comments in relation to the gear (Table 3: 3b). While the involvement of the industry in net storage, maintenance and rigging seems to be the main explanatory factor, the results of the industry survey (showing similar trends in catch rates for plaice and sole compared to the BTS) increased confidence in the quality and fitness-for-purpose of the BTS.

Survey coverage and planning

The other cluster of feedback themes is related to survey coverage (Table 3: 7a, b) and planning (Table 3: 6). In 2007 fishers commented that the survey did not cover a very specific area where plaice was abundant. Coverage was then extended to that specific area (Table 2: 1d), leading to positive feedback (Table 3: 7b). Negative feedback on survey coverage can also be explained by fishers' different perspectives on fishing. This may change over time, as Jan Drijver (skipper of TX9) illustrates: "You step on board as a fisher, but you actually have to learn how to think and work as a biologist. You have to change your whole mindset. The biologists on Tridens are as happy with a sea squirt as a basket of plaice." (Visserijnieuws, 23 September 2016).The timeframe for completion of the BTS, day-time fishing only and the extensive processing of all species caught (Table 3: 6) were also seen as limiting factors for getting a good spatial picture the plaice and sole fishing grounds. Most of this feedback was, however, only expressed in the first two years and ceased with the development of the industry survey. This remained so when the fisheries representatives decided to cease the industry survey time series: "The differences in patterns between the BTS and the industry survey were minor. We didn't see the added value in relation to the costs of running the industry survey. We were now confident in the quality of the BTS. The most important quality aspect was the fact that fishers are involved in checking and rigging the survey nets" (fishing representative). The comment also illustrates that fishers increasingly understand the relevance of the patterns in the survey, as opposed to absolute catch volumes.

Gateway function

The survey design of the BTS has remained constant and the presence of fishers as observers on the survey has only led to cosmetic changes in the gear design. Nevertheless, in the fishing fleet the story goes that "the BTS catches more plaice since, or rather because, fishers have joined the survey." This belief leads to more confidence in the survey results, and it goes beyond those fishers who are directly involved. We became aware of this perception because fisher observers, and also fishers we met in other situations, raised this point. This enabled us to discuss this preconception, and show how the actual increase in plaice catches is also seen in the catches of the International Bottom Trawl Survey (ICES, 2020c [Figure 13.2.10]) in the same area and season. This preconception also indicates that the survey as a methodological concept is still difficult to grasp for fishers who have not been actively involved (*cf.* Raicevich *et al.*, 2020). This is one of the reasons why the industry representatives, who are convinced about the survey's quality, want to continue giving fishers the opportunity to join as observers.

We found that fishers who joined the BTS gained more confidence in the survey as a direct result of their presence, regardless of the outcomes of the industry survey or the collaboration around the fishing nets. A similar observation was made following evaluation of a series of industry surveys in New England (DeCelles *et al.*, 2012). This increasing trust is related to three factors. First, throughout the week it becomes clear to the fisher observers that the survey consists of routines, proving that scientists carry out the survey in a standardized manner. Fishers mentioned this often during our chats on board, sometimes in their interview with *Visserijnieuws* and in our own interviews. Second, fishers are allowed to go everywhere on board the research vessel, help with the work and speak to everyone they wanted ("there is nothing to hide"). All observers use these opportunities freely. Last, but not least, fishers notice that we take their questions and comments seriously and take them into account where possible. The benefit of being on a ship together for a week is that discussions can be spread over a longer period and that there is time to look things up and to investigate some questions further.

An added benefit of this growing confidence in the survey is that fisher observers may take on a role raising awareness about the survey amongst their peers. For example, during a joint meeting on the set-up of the industry survey, some fishers had difficulty believing that during the BTS all catch is registered. Three fisher observers who had joined the BTS, spoke up and confirmed that the scientists were not joking. Another example occurred during the 2019 BTS. One of the scientists posted a short video of a rough sea on Twitter saying that we were postponing the day's first haul until the wind dropped. An influential fisher tweeted in response: "Have a look at the weather forecast before you go out like I do. Northerly winds are bad for catches." On his own initiative, the fisher observer later that day sent a Twitter response to this fisher: "That happened to be our best haul of plaice this

week". He later said (formal interview): "I look at [the survey] from a fisher's perspective and you from a scientist's perspective. That's a world of difference, but I want that... the fishers, so many have no clue what's happening here. I am here now and want to tell them, so I hope it is okay I share my experience on the fishers' WhatsApp-group. [Scientist confirms it is okay; fisher continues :]. I try to change things a bit. And then a guy like fisher X who is on Twitter and says: 'check the forecast before you start a survey'. I had to say something about that." Our interviews indicate that fisher observers only share their experiences in detail with their own crew or fishing company, when asked by others, or in the *Visserijnieuws* interviews. As such, their ambassadorship role is limited. Yet, examples as above suggest that fisher observers may take on a role of gatekeepers between the survey and their peers. Through their interactions with scientists and experiencing the survey they develop capacity as so-called "boundary spanners," who are able to communicate on both sides of the boundary between science and industry expertise, and are critical to successful knowledge exchange in collaborative research (Johnson, 2009).

The scientists' perspective

For scientists, taking fishers on board of the BTS was (and is) sometimes challenging. It may be difficult or painful to receive feedback on processes they have been doing for decades, especially from people other than fellow scientists. Yet, with the direct presence of the fishers on board, scientists became more aware that their work, including all explicit and implicit choices made, eventually impacts fishers' livelihoods. Close interactions led to increasing appreciation of how much is at stake for the fishers. Furthermore, the fishers' critical questions forced the scientists to have solid arguments for their various choices. It also inspired the scientists to continue thinking about the survey, its setup and the objectives. For the new generation of scientists on the BTS, having industry observers on board has become the standard. The short interviews with the science crew indicated that, "while sometimes it can be a bit annoying having them watching what you're doing," they enjoy the fishers' interest in their survey work, explaining it, discussing observations and findings, learning more about the fisher's daily operations, appreciate their assistance in sorting catch, and the social interactions during the survey. Moreover, sharing experiences, working and living together in the confinement of a ship for multiple days, contributes to developing social relationships and "boundary spanning" capacity (Johnson, 2009), which also post-survey will facilitate interactions between those involved.

Guidance for taking stakeholder observers on board fishery-independent surveys

Taking fisher observers (or other stakeholders) on board of fishery-independent surveys increases the industry's confidence in the survey results, and contributes to transparency, understanding of and communicating about each other's perspectives and mutual trust-building; all important aspects of co-producing knowledge in support of science-based management (Johnson and Van Densen, 2007; Johnson, 2009; Verweij *et al.*, 2010; Verweij and Van Densen, 2010; Stephenson *et al.*, 2016; Mangi *et al.*, 2018; Holm *et al.*, 2020; Österblom *et al.*, 2020; Steins *et al.*, 2020). Moving beyond the traditional data collection flow in SIRC (from fishers to science) by letting fishers experience "the scientists' domain," hence provides opportunities to strengthen such partnerships. Experiences elsewhere have shown that in cases where (industry) surveys were set-up as part of collaborative research projects and fishers' expertise was taken into account, scientists developed new insights useful for future data collection and the interpretation of data (Cotter, 2004; Johnson, 2009; DeCelles *et al.*, 2012). Equally, fishers were found to be more willing to accept the results, irrespective of whether these were favourable or not (DeCelles *et al.*, 2012). However, when fishers are involved in surveys and their access to understanding and contributing knowledge to the survey is tightly controlled or their expertise is treated as irrelevant or as non-scientific in an attempt to protect "the objectivity" of the data collection, this erodes confidence in science and legitimacy of decisions based on it (Johnson and McCay, 2012). The professional challenge for scientists in relation to involving fishers in fishery-independent surveys is therefore to organize this participation in such a manner that the scientific independence of the research survey remains intact, while at the same time taking fishers' expertise seriously. The focus should be on optimizing the credibility of the fishery-independent survey, resulting in confidence in the results, and hence its legitimacy.

To help others in their initiatives to collaborate and meeting professional challenges in this process, adding to guidelines for SIRC developed by Johnson and Van Densen (2007) and based on our experiences, we developed specific guidance for taking stakeholders on board of fishery-independent surveys on research vessels (Table 4). While in our case, taking fishers on board as observers was "the missing link" in an existing collaborative stock assessment project (Quirijns *et al.*, 2007), inviting fisher observers may also be the starting point for working towards mutual understanding and partnerships. In this context, in The Netherlands, stakeholder observership has recently been extended to other surveys, although not always on a regular basis, including the herring acoustic survey (Visserijnieuws, 2019), mackerel egg survey and freshwater survey at Lake IJsselmeer. We stress that the process of collaborating with fishers in surveys also has been a steep learning curve before the full value of inviting stakeholders on board became apparent. Although the context may differ per country or even institute, depending on the local approach to surveys as well as the (relation with) fishers, most guidelines should be applicable in all situations.

Our first guideline is "dare to share." Letting stakeholders on board as observers means providing them with the opportunity to understand what the work is about. Giving them full access to the research vessel and to the people on board as far as safety and specific regulations allow, shows that there is nothing to hide and scientists feel confident about their work. By giving full insight in the way things are done, the work procedures, the survey preparation and reporting, even if it is not perfect, it becomes clear that the scientific team knows what it is doing, and what the challenges are. Transparency on all survey aspects also increases fishers' feeling of responsibility for suggesting improvements and encourages informed discussions. Sharing also means talking about experiences and insights. Fishers, like most fisheries scientists, are fascinated about what happens in the sea. For example, a sudden change in recruitment or a species' distribution area will be noticed by both and is worth talking about. Communication is a key aspect of all SIRC (Johnson and Van Densen, 2007; Steins *et al.*, 2020), and this also applies to surveys. Communicate about the survey itself, before, during and afterwards. Whether it is a

Table 4. Guidelines for taking stakeholder observers on board of fishery-independent research vessel surveys.

1.	**Dare to share**
	a. Give full access to ship and all activities within safety regulations
	b. Be transparent about what you do
	c. Talk about experiences and insights
	d. Communicate about the survey from start to end in popular language
	e. Work with observers to share their experiences publicly
2.	Be clear
	a. Define roles and responsibilities of all people on board
	b. Inform the observer when the floor will be opened for questions
	c. Be aware of and explain the differences between fishery-independent research and commercial fishing
	d. Define the essential survey elements that should not be influenced by anyone without any agreement from the (inter)national coordinating body
	e. Acknowledge all observer comments, and explain what will/has been done with it, including why certain comments cannot be taken into account
	f. Be open about what you know and about what you do not know
3.	Be flexible
	a. Have an open mind
	b. Accept that protocols are not perfect and be willing to review
	c. Allow (if possible) for experimentation
	d. Accept that fishers (like scientists) often work on gut-feeling and take this seriously
4.	Be patient
	a. Accept that you will have to explain procedures and questions repeatedly
5.	Feel grateful
	a. Remember that all comments are a sign of interest in the work you do
	b. Remember feedback and dialogue improves your work
	c. Intensive interaction with stakeholders improves your communication skills
	d. Fishers spend valuable own time to join your survey and share their insights

weblog, the institute's website, the national fishing news, the newspaper, a radio interview, a combination of all, or other communication channels, make the survey understandable for laypersons. In these communications, find a way to share the observers' experiences with a wider audience. The national or local fishing news may be a good platform. Support publication of observers' views, even if these are not only positive. Ask for a preview of the publication, but only to check for factual inconsistencies to ensure that information about the survey itself is correct.

Second, "be clear." Point out the responsibilities and roles on board to the observers, to the ships' crew and to the scientific crew. When everyone knows their role, it is easier to stick to it. Also inform the observer upon arrival at what point the floor is open for asking questions about the survey. We recommend that an observer first experiences the full process from setting the net until sample processing. Opening the floor for questions after the first haul prevents discussions based on preconceptions (*cf.* Johnson, 2009). An important aspect of being clear, particularly when the observer is a fisher, is to be aware of the differences between fishery-independent research and commercial fisheries, and that this leads to a different view on "successful fishing." A survey is at the other end of the spectrum, which means that fisher observers first have to get acquainted with the survey methodology before they might be able to grasp the survey and its implications. Clarify the boundaries, differences between and value of both fishery-independent research and data collection from commercial fisheries. There is a need for both in stock assessment, and that should be clearly explained. It may be worth investing in information materials and communication on fish stock assessment, by giving presentations at fisheries meetings or at fisheries schools, by creating popular leaflets on stock assessment (e.g. Poos, 2014), online information modules on aspects of stock assessment and advice (e.g. Vistikhetmaar.nl, 2020), or a short animation (e.g. NOAA Fisheries, 2013).

Being clear also means defining and communicating the essential elements of the survey that should not be influenced by anyone. An important example is the station planning: this should be done in accordance with the survey protocol, which might result in fishing on locations where "no fish" can be found. The responsible scientist has to stick to the plan and should clearly explain why it is necessary to also sample at locations where the target species might be absent. Remember that while observers may have many comments, there is no need to always act upon them. Indeed, there may be good reasons for not taking them into account (e.g. financial constraints, time series consistency). Our advice is to listen to all comments and acknowledge the underlying expertise, and explain why feedback may not always be addressed directly in the survey. In communicating, scientists should be clear about what they know, as well as about knowledge gaps. For example, in relation to fish stock developments, some changes in patterns can be explained by clear interventions like changed management, but others may just happen without a (single) clear cause. Equally, some routine decisions during the survey may have been made a long time ago, and have not been documented at that time. Accept that this has happened. Questions may raise the scientist's own interest as well. In our case, interactions led to a further update of the existing protocols by explicitly incorporating a number of choices made at sea and adding more detailed information on the survey (Table 2: 1a–c).

Third, "be flexible." Taking stakeholder observers on board requires an open mind. Fishers have many questions, often based on many years of practical experience. They also have their individual interests, level of insight in the reasons for data collection, and level of trust in surveys or scientists. As a result, each survey period with an observer will be different. Also accept that protocols can always be improved, although a lot of time and effort may have been spent to write them down. Be willing to go back and review, based on the observers' comments. Sometimes a comment just arises from unclarity, and concerns can be easily taken away. In addition, and if possible, allow for experimentation and flexibility to put requests by the observers into action. For example, carry out a comparative haul with a nearby fishing vessel. It shows fishers' concerns are taken seriously even though the activity is not a solution in itself. Similarly, appreciate that fishers often work on gut-feeling, and realize that this is often based on a lot of experience at sea. It may lead to a focus on topics that to the scientists seem less important, but addressing concerns sincerely may make a world of difference to the research collaboration. For example, making a cosmetic change (e.g. in a

survey net, in the protocol) may not make sense to scientists (or worth the effort), but by implementing those changes such contributions are recognized as being valuable. Be clear though that even cosmetic changes sometimes require testing first. Explain that this has to be done to justify the change, and to ensure credibility of the data series in the scientific context. By allowing the experiment, scientists show that there is a willingness to explore the effect of proposed changes.

Four, "be patient." It is inevitable that scientists welcoming stakeholders on board have to explain aspects of the survey more than once (read: over and over again), even to observers who have repeatedly joined. Examples include: why the gear is as it is, why it cannot be changed, why from a survey perspective "null" catches are as important as hauls with a lot of (target) fish. Just do it, consistently, with an open mind, and every time again with the same dedication. Rome was not built in 1 day either.

Finally, "feel grateful." Intensive exchanges with observers will benefit scientists' communication skills. It may be difficult to always envisage the observers' comments as a gift, as they can be very critical. Although the initial reaction to comments may be to feel frustrated or take it personal, remember that the survey is apparently of interest to fishers and influences their fishing opportunities and way of life. Why else would they would spend a week or more away from earning a living and observing the scientists' work. When a fisher asks a lot, or likes discussing certain topics, it is usually a sign of genuine interest.

Conclusions

Science-industry research collaboration in fisheries is gradually moving beyond tapping the potential of fishers as sources for additional data towards genuine co-production of knowledge (Stephenson *et al.*, 2016; Bentley *et al.*, 2019; Holm *et al.*, 2020; Steins *et al.*, 2020). Yet, in many SIRCs, the flow of knowledge in relation to actual data collection remains largely unidirectional. Inviting stakeholders on board a fishery-independent survey is a valuable addition to SIRC. First, hands-on insight in the survey methodology and involvement in survey activities contribute to more constructive discussions about fishery-independent data collection. Second, seriously reviewing possibilities for addressing observers' comments and being transparent, leads to increasing trust in the survey results and in the scientific and vessel crew. Third, sharing survey experiences also leads to agreement that fishers and scientists have different perspectives on successful fishing. This recognition is key for industry support for fish stock surveys and resulting stock assessments. For the observers, it is still difficult at times to emotionally accept that the survey fishes in areas "without fish"; yet they cognitively do understand and accept the background of the survey setup. For the scientists, it sometimes remains challenging to deal with recurring comments, but interactions result in better understanding on how their work impacts the fishers. Finally, giving stakeholders the opportunity to look behind the scenes of a survey on a research vessel contributes to a more reciprocal relationship in SIRC partnerships aimed at data collection, increases they survey's legitimacy and thus supports buy-in for science-based management. If scientists dare to share, be clear, flexible and patient, and, last but not least, feel grateful (our guidelines) fishers, and scientific surveys are compatible, and fishers' expertise can both literally and figuratively be taken on board without compromising the survey's and professional credibility.

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Dedication

We dedicate this article to fisher Wim de Boer (UK104, Rederij L. de Boer & Zonen BV) and our former colleague Wim van Densen (Wageningen Marine Research). Both passed away in 2020 and were true ambassadors for research collaboration amongst their peers. They worked tirelessly on bridging the gap between fisher and scientific knowledge. They changed the mind-sets of fishers and scientists and are the founding fathers of our ongoing collaboration.

Data availability

Visserijnieuws articles (all in Dutch) used for the analysis and not included in the reference list are available online (www.visserijnieuws.nl) or in hardcopy from the corresponding author. Meeting reports and interview summaries (all in Dutch) are available from the corresponding author, upon reasonable request, and under condition that all names are anonymized.

References

Bentley, J. W., Serpetti, N., Fox, C., Heymans, J. J., and Reid, D. G. 2019. Fishers' knowledge improves the accuracy of food web model predictions. ICES Journal of Marine Science, 76: 897–912.

Berkes, F., and Folke, C. 2000. Linking social and ecological systems. *In* Management Practices and Social Mechanisms for Building Resilience. Ed. by F. Berkes, and C. Folke. Cambridge University Press, Cambridge. 459 p.

Cotter, J. 2004. Can fishers teach scientists how to improve fish surveys? Selected results from spatially intense, commercial FV surveys of nine English fisheries in 2003-4. Working Paper 5. *In* ICES (Ed.), Report of the Working Group on Survey Design and Analysis (WKSAD), Aberdeen, 21–25 June 2004. ICES CM 2004/B:07, Ref. D, G. 261 pp.

De Boois, I. J. 2011. Vergelijkingen BTS netten. CVO Memo, 21 April 2011. CVO/11.IMA0294.IB.mb.

DeCelles, G., Roman, S., Barkley, A., and Cadrin, S. 2012. Forming collaborative partnerships to improve fisheries research surveys. Paper presented at the ICES International Science Conference, Bergen, Norway, 17-21 September 2012, ICES CM 2012/F0:03.

Degnbol, P. 2003. Science and the user perspective: the gap co-management must address. *In* The Fisheries co-Management Experience. Accomplishments, Challenges and Prospects, pp. 31–49. Ed. by D. C. Wilson, J. R. Nielsen and P. Degnbol. Dordrecht: Kluwer Academic Publications.

Dinklo, I. 2006. Fabels en feiten over kwalitatieve onderzoeksresultaten: hardnekkige misverstanden over generaliseren van kwalitatieve onderzoeksuitkomsten. KWALON, 32: 35–43.

Funtowicz, S. O., and Ravetz, J. R. 1993. Science for the postnormal age. Futures, 25: 739–755.

Holm, P., Hadjimichael, M., and Mackinson, S. 2020. Bridging the Gap: Collaborative Research Practices in the Fisheries. MARE Publication Series 22. Springer, Amsterdam. 320 p.

ICES. 2005. Report on the Study Group on Survey Gear Standardisation (SGSTS). Rome, 16-17 April 2005. ICES CM 2005/B:02, Ref D, G. WGFTB.

ICES. 2018. Interim Report of the Working Group on Marine Litter (WGML), 23–27 April 2018, ICES Headquarters, Copenhagen, Denmark. ICES CM 2018/HAPISG:10. 90 pp.

ICES. 2019. Manual for the Offshore Beam Trawl Surveys, Version 3.4, April 2019, Working Group on Beam Trawl Surveys. 54 pp. doi: 10.17895/ices.pub.5353.

ICES. 2020a. ICES Advice 2020 – ple.27.420. doi: 10.17895/ices.advice.5910.

ICES. 2020b. ICES Advice 2020 – sol.27.4. doi: 10.17895/ices.advice.5946.

ICES. 2020c. Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK). ICES Scientific Reports. 2:61. 1140 pp. doi: 10.17895/ices.pub.6092.

Jentoft, S., and Chuenpagdee, R. 2009. Fisheries and coastal governance as a wicked problem. Marine Policy, 33: 553–560.

Johnson, T. R., and Van Densen, W. L. T. 2007. Benefits and organization of cooperative research for fisheries management. ICES Journal of Marine Science, 64: 834–840.

Johnson, T. R. 2009. Cooperative research and knowledge flow in the marine commons: lessons from the Northeast United States. International Journal of the Commons, 4: 251–272.

Johnson, T. R., and McCay, B. J. 2012. Trading expertise: the rise and demise of an industry/government committee on survey trawl design. Maritime Studies, 11: 14.

Kaplan, I. M., and McCay, B. J. 2004. Cooperative research, co-management and the social dimension of fisheries science and management. Marine Policy, 28: 257–258.

Mackinson, S., and Van der Kooij, J. 2006. Perceptions of fish distribution, abundance and behaviour: observations revealed by alternative survey strategies made by scientific and fishing vessels. Fisheries Research, 81: 306–315.

Mackinson, S., Wilson, D. C., Galiay, P., and Deas, B. 2011. Engaging stakeholders in fisheries and marine research. Marine Policy, 35: 18–24.

Mangi, S., Kupschus, S., Mackinson, S., Rodmell, D., Lee, A., Bourke, E., Rossiter, T., *et al.* 2018. Progress in designing and delivering effective fishing industry-science data collection in the UK. Fish and Fisheries, 2018: 1–21.

NOAA Fisheries. 2013. The ABC of stock assessments (animation). www.youtube.com/watch?v=3UbWMdpavUE (last accessed 1 August 2020).

Österblom, H., Cvitanovic, C., Van Putten, I., Addison, P., Blasiak, R., Jouffray, J. B., Bebbington, J., Hall., *et al.* 2020. Science-industry collaboration: sideways or highways to ocean sustainability? One Earth, 3: 79–88.

Pearson, E., Hunter, E., Steer, A., Arscott, K., and Hart, P. B. J. 2020. Fishermen and scientists in the same boat. A story of collaboration in the UK South Devon crab fishery. *In* Bridging the Gap: Collaborative Research Practices in the Fisheries, pp. 27–41. Ed. by P. Holm, M. Hadjimichael and S. Mackinson. MARE Publication Series 22, Springer, Amsterdam, 320 p.

Poos, J. J. 2014. Hoe werkt een bestandschatting? Brochure van ProSea en IMARES Wageningen UR. https://edepot.wur.nl/421964 (last accessed 1 August 2020).

Productschap Vis. 2007. Verslag van het overleg IMARES-LNV-visserijsector over de onderzoekssamenwerking (OSW) gehouden op 3 juli 2007 in het Visserijcentrum te Rijswijk.

OSW. 2009. Conceptverslag van het OSW-overleg van 23 November 2009, onderdeel evaluatie BTS, gehouden in IJmuiden.

Quirijns, F. J., van Keeken, O. A., and van Densen, W. L. T. 2007. 5 years of F-project: a final report. IMARES Report number C058/07.

Quirijns, F. J., de Boois, I. J., Bierman, S., and Rink, G. 2010. Traject Bedrijfssurvey; fase 1: draagvlak and haalbaarheid. IMARES Report number C035/10.

Quirijns, F. J., and Miller, D. 2011. Traject Bedrijfssurvey; fase 2: vergelijkend vissen. IMARES Report number C094/11.

Raicevich, S., Dubois, M., Bullo, M., Franceschini, G., Mion, M., Nalon, M., Piras, C., *et al.* 2020. The Italian job: Navigating the (im)perfect storm of participatory fisheries research in the Northern Adriatic Sea. *In* Bridging the Gap: Collaborative Research Practices in the Fisheries, pp.121–140. Ed. by P. Holm, M. Hadjimichael and S. Mackinson. MARE Publication Series, 22, Springer, Amsterdam. 320 p.

Rasenberg, M., Quirijns, F., Machiels, M., Nijman, R., Westerink, H. J., and Wiegerinck, H. 2012. Bedrijfssurvey 2011. IMARES Report number C054/12.

Rasenberg, M., and Machiels, M. 2013. Verslag Bedrijfssurvey 2012. IMARES Report number C008/13.

Rasenberg, M., Machiels, M., Nijman, R., Wiegerinck, H., and., and Rink, G. 2014. Bedrijfssurvey 2013. IMARES Report number C010.14.

Röckmann, C., van Leeuwen, J., Goldsborough, D., Kraan, M., and Piet, G. 2015. The interaction triangle as a tool for understanding stakeholder interactions in marine ecosystem based management. Marine Policy, 52: 155–162.

Stauffer, G. (compiler). 2004. NOAA protocols for groundfish bottom trawl surveys of the nation's fisheries resources. US Department of Commerce, NOAA Technical Memorandum NMFS-F/SPO-65. http://spo.nmfs.noaa.gov/tm/.

Steins, N. A., Kraan, M. L., Reijden, K. J., Quirijns, F. J., Broekhoven, W., and Poos, J. J. 2020. Integrating collaborative research in marine science: recommendations from an evaluation of evolving science-industry partnerships in Dutch demersal fisheries. Fish and Fisheries, 21: 146–161.

Stephenson, R. L., Paul, S., Pastoors, M. A., Kraan, M., Holm, P., Wiber, M., Mackinson, S., *et al.* 2016. Integrating fishers' knowledge research in science and management. ICES Journal of Marine Science, 73: 1459–1465.

Van der Reijden, K. J., Wiegerinck, J. A. M., Rink, G. J., Machiels, M. A. M., and Rasenberg, M. M. M. 2014. Verslag bedrijfssurvey 2014. IMARES Report C184/14.

Van der Reijden, K. J., Rink, G. J., Dammers, M., Wiegerinck, J. A. M., and Van Hal, R. 2015. Verslag bedrijfssurvey 2015. IMARES Report C177/15.

Van der Reijden, K. J., Poos, J. J., Trapman, B. K., and Verkempynck, R. 2016. 5 years of Industry survey: does the industry survey improve current stock assessments for plaice and sole? Wageningen, IMARES Wageningen UR (University and Research centre), IMARES Report C039/16.

Verweij, M. C., van Densen, W. L. T., and Mol, A. J. P. 2010. The tower of Babel: different perceptions and controversies on change and status of North Sea fish stocks in multi-stakeholder settings. Marine Policy, 34: 522–533.

Verweij, M. C., and Van Densen, W. L. T. 2010. Differences in causal reasoning about resource dynamics and consequences for the participatory debate on North Sea fisheries. Marine Policy, 34: 1144–1155.

Visserijnieuws. 2007a. Ra ra? Scholvisserij beter, vangstadviezen lager. Visserijnieuws, 6 March 2007. https://www.visserijnieuws.nl/nieuws/frustratie-bij-vissers-en-wetenschappers (last accessed 19 January 2019).

Visserijnieuws. 2007b. Waarnemers aan boord. Beter scholbeeld. Visserijnieuws, 31 August 2007. https://www.visserijnieuws.nl/nieuws/waarnemers-aan-boord (last accessed July 2018).

Visserijnieuws. 2007. Oostelijker meer schol. Visserijnieuws, 7 September 2007. https://www.visserijnieuws.nl/?search=oostelijker%20meer%20schol (last accessed July 2018).

Visserijnieuws. 2007. Survey is momentopname. Visserijnieuws 27, 21 September 2007.

Visserijnieuws. 2008. Rol voor visserijsector bij platvissurveys. Visserijnieuws 28, 1 August 2008.

Visserijnieuws. 2010. Verschrikkelijk veel tongbroed. Visserijnieuws 30, 20 August 2010.

Visserijnieuws. 2012. Hele lengteverdeling bemoedigend. Visserijnieuws, 8 September 2012. https://www.visserijnieuws.nl/nieuws/hele-lengteverdeling-bemoedigendboomkorsurvey-tridens-en-isis-mooi-op-schema (last accessed 28 July 2018).

Visserijnieuws. 2016. Veel broed gezien. Visserijnieuws 36, 23 September 2016.

Visserijnieuws, 2019. Haringsurvey met echometers, otolieten en DNA. Visserijnieuws, 13 September 2019. https://www.visserijnieuws.nl/nieuws/haringsurvey-met-echometers-otolieten-en-dna (last accessed 1 August 2020).

Vistikhetmaar.nl. 2020. Dossier Vangstadvies. www.vistikhetmaar.nl/dossiers/vangstadvies (last accessed 1 August 2020).

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