ICES Journal of Marine Science, 2022, **0**, 1–14
DOI: 10.1093/icesjms/fsac016
Original Article

Being able is not necessarily being willing: governance implications of social, policy, and science-related factors influencing uptake of selective gear

Nathalie A. Steins [1,*], Alessa L. Mattens [1,2] and Marloes Kraan [3,4]

[1]Wageningen Marine Research, Wageningen University and Research, Haringkade 1, 1976 CP IJmuiden, Netherlands
[2]AERES Hogeschool, Faculty Almere, Aboretum West 98, 1325 WB Almere, Netherlands
[3]Wageningen Economic Research, Wageningen University and Research, Droevendaalsesteeg 4, 6708 PB Wageningen, The Netherlands
[4]Environmental Policy Group, Wageningen University and Research, Hollandseweg 1, 6706 KN, Wageningen, Netherlands

[*] *Corresponding author: tel: +31 317 487092;* e-mail: nathalie.steins@wur.nl

Improving the selectivity of fishing gear and practices has been a challenge for fishers, scientists, and policy-makers for decades. In Europe, urgency increased with the introduction of the landing obligation. Voluntary uptake of proven selective gears has been poor across the globe. To increase uptake levels, a move from science-led to industry-led development of selective gears has been advocated. In the Netherlands, gear innovation has, since the mid-2000s, been fisher-led. Nevertheless, this did not result in the assumed increase in uptake. Our qualitative study amongst Dutch demersal fishers shows that decisions to voluntarily adopt proven fishing gear are driven by a complex interplay of social, policy, and science-related factors. These can be attributed to two behavioural components: Willingness and Ability. Willingness, our study showed, is closely linked to: (i) intrinsic motivations and beliefs about sustainable fishing as well as perceptions about the motivations and behaviour of other fishers; (ii) the extent to which fishers consider policy goals and regulations as legitimate; and (iii) strong normative beliefs amongst fishers about the presence (or absence) of a level playing field, in terms of both the same rules applying to all and trust in compliance and enforcement. Ability is associated with knowledge, skills, economic, and legal possibilities to enable voluntary uptake, and tends to be the focus of science and policy. We conclude that a narrow focus on Ability as a driver for encouraging selective fishing is unlikely to result in real changes, and recommend a stronger emphasis on addressing social, policy- and science-related factors associated with Willingness in encouraging more selective fisheries.

Keywords: bycatch avoidance, fisher behaviour, fishing technology, incentives, landing obligation, selective gear, trust.

Introduction

Fishers continuously work on their gear; the rigging and shape of nets is the result of years of tweaking and testing. They have in-depth "experiential knowledge" (Stephenson *et al.*, 2016) of how to optimize landings of target species and adapt to seasons and fishing grounds, whilst considering market demands and regulations. These regulations continuously challenge fishers to make adaptations in where and how they fish, to reach policy goals such as safeguarding healthy stocks, protecting biodiversity and minimizing impact on the marine environment. In this context, improving the selectivity of fishing gear and practices to reduce unwanted by-catches has for decades been a global, ongoing challenge for fishers, scientists, and policy-makers (Anon., 1989; Kennelly & Broadhurst, 2002; Walsh *et al.*, 2002; Kennelly, 2007; FAO, 2011). The development of more selective fisheries in the European Union is now encouraged by the introduction of a landing obligation (Anon., 2013). This requires fishers to land unwanted by-catches of regulated species, previously discarded at sea. This requirement should incentivize fishers to develop more selective fishing techniques and practices to reduce the additional costs associated with landing unwanted by-catch (Penas Lado, 2016; Uhlmann *et al.*, 2019). The landing obligation was phased in between 2013 and 2019. Its objective of more selective fisheries is still far from achieved due to a complex interplay of social, cultural, economic, technical, and institutional factors (Uhlmann *et al.*, 2019). Nevertheless, its introduction and associated public funding to improve selectivity reinvigorated efforts by fishers, industry organisations, scientists, and policy-makers to work on fishing gear modifications to reduce unwanted by-catch (Molenaar *et al.*, 2016; Mortensen *et al.*, 2017; Calderwood *et al.*, 2021; ICES, 2021).

However, as years of world-wide gear technology studies show, voluntary uptake of so-called "proven fishing gear" (Eayrs & Pol, 2019) is low or not happening at all. The poor voluntary uptake of proven fishing gear has puzzled scientists and policy-makers around the world. It can be linked to a number of factors covering social aspects (comprising cultural, historic, economic, and behavioural factors), and policy- and science-related aspects. These are often interlinked and include seeking short-term economic benefits over considering long-term advantages (Graham *et al.*, 2007; Catchpole *et al.*, 2008; S. J. Hall & Mainprize, 2005; Jennings & Revill, 2007; Suuronen & Gilman, 2020), investment costs (Jennings & Revill, 2007; ICES, 2018; Eayrs & Pol, 2019), resistance to change (Suuronen & Sardà, 2007; Eayrs *et al.*, 2015; Eayrs & Pol, 2019), community norms such as negative perceptions of innovative behaviour by fellow fishers (Eliasen *et al.*, 2014; ICES, 2018), historical mistrust between parties involved (Penas Lado, 2016; ICES, 2018; Eayrs & Pol, 2019), lack of

Received: October 28, 2021. **Revised:** December 22, 2021. **Accepted:** January 24, 2022

(shared) understanding of "the discards problem" and its ecological and economic consequences (Catchpole *et al.*, 2008; Eliasen *et al.*, 2014), lack of appropriate incentives or presence of disincentives (Jennings & Revill, 2007; Catchpole *et al.*, 2008; Eliasen *et al.*, 2014; Penas Lado, 2016; ICES, 2018; Eayrs & Pol, 2019; Suuronen & Gilman, 2020), top-down and "one size fits all" approaches of policy implementation and lack of support for policy goals, (Graham *et al.*, 2007; Barz *et al.*, 2020; Calderwood *et al.*, 2021; S. J. Hall & Mainprize, 2005; Kraan *et al.*, 2015; Penas Lado, 2016; Kraan & Verweij, 2020), ineffective outreach by scientists to inspire fishers to adopt proven gear (Eayrs & Pol, 2019; S. J. Hall & Mainprize, 2005), and poor levels of meaningful fisher involvement in the design, testing and decision-making process (Calderwood *et al.*, 2021; S. J. Kennelly & Broadhurst, 2002; Hall & Mainprize, 2005; Kraan *et al.*, 2015; ICES, 2018; Veiga-Malta *et al.*, 2019).

Recently, science and industry actors have sought ways to address the science related aspects influencing the voluntary uptake of proven gear. Traditionally, the development of more conservation-oriented fishing gear technology has been characterised by a top-down approach in response to regulatory challenges (Walsh *et al.*, 2002; ICES, 2018). This usually puts scientists in the lead, bringing in fishers to share ideas and expertise, assist in testing gears (either on research vessels or commercial vessels), contribute to data collection and evaluation, and serve as project ambassadors for their peers. Fisher involvement mainly serves to increase relevance of projects and increase legitimacy (Kennelly & Broadhurst, 2002; ICES, 2018; Eayrs & Pol, 2019). Active fisher involvement in all stages of selective gear development differs between countries, with gear technologists generally dominating the process and a strong focus on promoting proven gear. This is illustrated by the emphasis put on improving outreach and extension to inspire fishers to adopt proven gear, and where the general failure to find "strategies, models, or approaches […] to encourage the voluntary uptake of proven fishing gear [causes] frustration and bewilderment […] amongst […] fishing gear technologists" (Eayrs & Pol, 2019). More recently, science-led approaches have gradually given way to industry-led projects, where fishing industry organisations or companies lead the process of selective gear development. This new role for industry is seen as a potential way to increase the number and uptake of gear modifications (ICES, 2018; Veiga-Malta *et al.*, 2019).

This change in approach has also taken place in the Netherlands. Until the mid-2000s, commercial fishing gear technology research followed a similar thematic evolution as in the international context of the International Council for the Exploration of the Seas (ICES) (Walsh *et al.*, 2002). Research into commercial fishing gear development in these periods always involved fishers, for example, in designing and mending nets, but was driven by the Dutch fisheries research institute. Trials took place on research vessels and occasionally on commercial vessels. A financial and image crisis in the Dutch North Sea demersal fisheries (van Hoof *et al.*, 2020) triggered a fundamental change in approach. From the mid-2000s onwards, fishing gear development became primarily industry-led; fishers design, test, and further develop gear modifications themselves with scientists in a supportive role. With this new approach scientists, industry representatives and policy-makers envisaged that a larger suite of effective selectivity measures would be developed as well as more buy-in from industry. They assumed that this would result in increasing voluntary uptake of proven fishing gear. This was, however, not the case. An example of a proven fishing gear, developed in this new way in the North Sea nephrops (*Nephrops norvegicus*) fishery, is the SepNep. The SepNep leads to significant reduction of unwanted by-catch of plaice (*Pleuronectus platessa*) (65%), dab (*Limanda limanda*) (79%) and undersized nephrops (53–56%) with marginal loss of commercial catch (Molenaar *et al.*, 2016). Although the SepNep's benefits are recognised by fishers, there is no sign of its voluntary uptake; even the fisher who developed it is no longer using it. The same phenomenon occurs for other gear modifications in the demersal fisheries.

Understanding the underlying mechanisms that stop fisher-led development of selectivity measures from leading to the voluntary uptake of proven fishing gear is important given the implementation of European Common Fisheries Policy (CFP) and spending of public funding. While over the years, gear technologists, industry representatives and policy-makers in the Netherlands came forward with "educated guesses" based on hearsay or informal chats with fishers, a much-needed systematic investigation of fishers' views and motivations was lacking. Indeed, comprehensive evaluations of fishing gear technology uptake tend to be based primarily on input from scientists, industry representatives (as spokespersons for fishers) and policy makers without direct input from fishers (ICES, 2018; Eayrs & Pol, 2019). This study instead explores the views of Dutch demersal fishers on the voluntary uptake of proven selective fishing techniques. We defined a selective fishing technique as an adaptation in existing nets or gears with the objective of reducing unwanted fish by-catch of regulated species. Fishers' views were collected through a combination of interviews and a survey. We show how voluntary uptake of proven gear is driven by an interplay of social, policy- and science-related factors, and that these can be attributed to two behavioural components: Willingness and Ability to change. The latter tends to be the focus of science and policy in relation to encouraging more selective fisheries. For real change, the former also needs to be addressed.

Methods

We used a mixed methods approach to data collection, consisting of interviews and an online survey, and a stepwise analysis. Interviews enabled us to develop an initial understanding of different factors that influence fishers' decisions to voluntarily take up proven fishing. A follow-up online survey allowed us to explore the views from a larger group of fishers, including those who had not been involved in gear technology research.

Interviews and initial analysis

A total of 16 interviews with stakeholders were carried out, including 9 demersal fishers involved in selectivity research in the past decade, as well as industry and policy representatives and scientists (Table 1). An interview guide with semi-structured questions was developed for each stakeholder group (Supplementary Material S1). They focused on the development of selective fishing techniques, (dis)advantages of new techniques, motivations to adopt (or not) new techniques, (dis)incentives to voluntarily adopt selectivity measures, collaboration with science, and policies in relation to technical measures. Interviews took place by telephone or videoconfer-

Table 1. Breakdown of interviewees.

Category	Number
Demersal fishers:	(9)
Flatfish (*Pleuronectus platessa, Solea solea)*	3
Brown shrimp (*Crangon crangon*)	2
Combined gears in demersal trawl fisheries (*Nephrops norvegicus*/brown shrimp (1); nephrops/brown shrimp (1); brown shrimp/flatfish (1)	3
Stow net	1
Industry representatives	2
Scientists	(5)
Netherlands	4
Other EU country	1
Policy-makers	1

Table 2. Breakdown of respondents of fisher survey

Role (rows) and current fishery (columns)	Skipper-owner (fishing)	Skipper employed by fishing company	Land-skipper (own company)	Crew	Retired	Total
Beam-trawl with tickler chains (flatfish)	2	1	2			**5**
Sum-wing with tickler chains (flatfish)	2					**2**
Pulse trawl* (flatfish)	2		1			**3**
Twinrig (flatfish)	1	1				**2**
Quadrig (nephrops)	2					**2**
Shrimp trawl	7	1	1	1		**10**
Shrimp Seewing	2					**2**
Flyshoot (non-quota species)		1	1			**2**
Rod-and-line (sea bass)	1					**1**
Other (former fisher)					1	**1**
Total	**19**	**4**	**5**	**1**	**1**	**30**

*Survey sent prior to ban on pulse trawling in the European Union from 1 July 2021 (Anon., 2019) onwards.

ence due to COVID-19 restrictions. They were not recorded. Extensive notes were taken, and an interview summary was made immediately after. All interviewees had the opportunity to review the written, anonymized summary of their interview. The interviewee from the policy sector participated under the conditions that information provided was regarded as personal views, not to be attributed to the government department; quoting from this interview was not allowed.

Interviews were thematically analysed with responses grouped together in five themes: (i) research collaboration on gear technology; (ii) involvement in selective fishing practices; (iii) reasons for (lack of) voluntary uptake of proven gear; (iv) what is needed to encourage uptake of selectivity measures; and (v) regulations and voluntary uptake of selective fishing gear. These themes correspond with the headings of the subsections under Results. The grouped thematic responses from the interviews were then used to develop an online survey aimed at demersal fishers.

Survey and subsequent analysis

The online structured survey (Microsoft Forms) consisted of 24 questions and statements (Supplementary Material S2). These were phrased based on findings from the interviews allowing for direct comparability. Most response options were multiple choice, to as much as possible lower potential barriers to respond (e.g. available time, using a smartphone keyboard). The survey included some (non-mandatory) open-ended questions to allow fishers to elaborate on responses if they wished. It also included a comment box for any additional input (optional). All responses were anonymous. Prior to distribution, the survey was tested by two research technicians; this included checking whether questions were clear and whether completion time could be within 15 minutes. The survey was distributed to the demersal fleet via the online newsletters of the two national fisheries associations (total distribution includes about 620 fishers), a fishers' WhatsApp group (EMK, 223 group members), and via the social media outlets of Wageningen Marine Research and some of the authors. Response time was two weeks. This resulted in 30 responses from different demersal fleet segments (Table 2), including the fisheries for flatfish (12) and brown shrimp (12). Most respondents were active fishers (24). The majority (18) had been actively involved in the development of selective fishing gears or had voluntarily taken up more selective fishing techniques (17). Only 6 had done neither.

Responses to the online form were exported to Microsoft Excel. Results from both the open and the closed questions were allocated to the five themes identified from the interviews. We then compared interview and online survey findings. For the third theme, reasons for (lack of) voluntary uptake, we allocated the responses to three categories: (i) social (cultural, historic, economic, and behavioural); (ii) policy; and (iii) science. We identified these categories from reviewing the peer-reviewed literature in relation to selectivity research of proven gear uptake. During this analysis, we found that reasons for voluntary uptake differ in nature. Some are related to being able to change and others to being willing to make the change. We then also grouped the categorised reasons for (lack of) voluntary uptake to two behavioural components Ability and Willingness. We did the same for the fourth and fifth

theme. A schematic overview including our findings is shown in the Discussion section.

Representativeness of interview and survey data

The interviews and survey aimed to gain insight into what drives or hinders voluntary uptake of more selective fishing techniques. In this context, it is important that interviews and survey results are representative. In qualitative social science research, representativeness means that research results reflect or give a complete picture of the possible opinions, attitudes or behaviours occurring in the total research population (Dinklo, 2006). The number of interviews amongst fishers is small compared to the total number of Dutch demersal fishers and its different métiers; and even within métiers, heterogeneity of fishers is large (Schadeberg *et al.*, 2021). Also, the interviews were purposefully sampled, with fishers who had experience in selectivity research. However, we found frequently recurring opinions and saturation of information with the increasing number of interviews. This means that, despite the small sample size, we are confident the results are indicative of the views of Dutch demersal fishers with an interest in more selective fishing. Interview results are therefore also usable for further qualitative analysis and for developing questions for the structured survey for fishers. Similar considerations apply to the interview results from the representatives of the fisheries associations and the scientific community; only for policy are qualitative representativeness criteria unmet.

The online survey was not sent through a targeted mailing but through various online group channels. Only 30 fishers responded, although the Dutch demersal fleet comprises of over 300 vessels, with crew numbers per vessel varying from 2 to 6 crew (van Hoof *et al.*, 2020). Potential explanations for this low response include: (i) use of generic social media mailing instead of a personal invitation to participate; (ii) a relative short response deadline; and (iii) demotivation to participate in research following the European ban on pulse fisheries (Anon., 2019). Pulse fishing was a gear innovation in the North Sea beam-trawl fishery for Dover sole "where the mechanical stimulation by tickler chains is replaced by electrical stimulations to reduce adverse ecological and environmental effect and fuel costs" (Rijnsdorp *et al.*, 2020). The impact of the pulse ban on the willingness to participate in the online survey was reflected in discussions on the fishers' WhatsApp group following the posting of its weblink Three separate group members informed us that many group members were questioning why they should cooperate in our study and some even called for a "boycott" considering what happened with the pulse trawl. A survey response rate of 10% is too low for statistical analysis (Nooij, 1990), but results can be used in qualitative analysis and discussion. The surveys also add insights to the interview data as they include perspectives from fishers who had neither been involved in selectivity research nor in voluntary take-up of proven gears.

Results

Research collaboration on gear technology

The current, industry-led approach to fishing gear technology research in The Netherlands was triggered by an existential crisis in the North Sea beam-trawl fishery (van Hoof *et al.*, 2020). A task force advised the government on the development of an economic and ecologically sustainable perspective for the fleet. This included, amongst other things, a focus on fishing gear innovation to improve selectivity, reduce benthic impacts and lower fuel consumption (Task Force Duurzame Noordzeevisserij, 2006). Subsequently 45 million euros to promote fisheries innovation was allocated. A Fisheries Innovation Platform was set up to encourage innovation and to asses project grant proposals. One of its activities to change fishers' mindsets towards more sustainable fisheries was setting up Fisher Knowledge Networks (Quirijns *et al.*, 2019; van Hoof *et al.*, 2020). These Networks operated independently from fisheries associations and their membership crossed the boundaries of fishing ports. Fishers who would normally not interact, but shared a common interest, pooled their knowledge and worked on resolving challenges(de Vos & Mol, 2010). All results had to be shared publicly. This new national approach for fisheries innovation also affected the approach to fishing technology research: fishing companies and organisations themselves became in the lead, with the fisheries institute having a supportive role in the collaboration. These changing roles in fishing technology research were facilitated by the increasing level of trust between the industry and scientists developed in research collaboration projects on fish stock assessment (Steins *et al.*, 2020). The new approach further evolved after the Fisheries Innovation Platform ended in 2011. While the innovation agenda at the time focused on the pulse fishery (Haasnoot *et al.*, 2016), the introduction of the landing obligation kept the development of selectivity measures high on the agenda. Nowadays, in a typical Dutch gear innovation research project, industry organisations submit the grant proposal and coordinate the consortium. Fishers develop gear modifications, including (iterative) testing and self-sampling. Scientists provide advice and assess gear performance (observer trips) once fishers are confident modifications are working. Results from self-sampling and observer trips are jointly discussed and reported. Research predominantly takes place on commercial vessels. This type of industry-led research brings about challenges (Veiga-Malta *et al.*, 2019; Steins *et al.*, 2020), but both fishers and scientists value this new form of collaboration. Fisher A: "*The past 10–15 years, researchers and fishers have gotten closer together. […This] has improved communication and we listen much better to one another. That results in better solutions.*" Scientist 1: "*Fishers generally appreciate my work. [It] is advantageous for the fishery. This means they have a positive attitude and want to cooperate. […] Fishers are capable of monitoring commercial catches but catch composition of discards ultimately must be done by us. It is a long process to develop a selective technique, but it is very interesting to bring different opinions and visions together into one solution. […] Building trust is really important.*" The importance of building and maintaining trust was also mentioned in three interviews with fishers. However, contrary to what was anticipated, the new policy and science approach has not resulted in increased voluntary uptake of proven gear.

Involvement in selective fishing practices

All interviewees were selected based on past or current contributions in selectivity research. The survey respondents (n = 30) also showed a high involvement in more selective practices. Nearly all respondents (93%) were currently working on selective practices. Eighteen respondents have been or are involved in research projects into selectivity, most of them

in the flatfish fisheries. Projects included the development of escape panels in the brown shrimp and flatfish gears, pulse fisheries research, the SepNep, use of different yarns and bigger mesh size, adaptations to the design of the traditional beam-trawl, and trials with semi-pelagic otter-boards. The majority of the 18 fishers who have been involved in selectivity research also have at times adopted modifications voluntarily (61%). Amongst the 12 fishers who never participated in selectivity research, 6 voluntarily adopted gear modifications developed by their colleagues and 76% of all respondents voluntarily took up selectivity measures and were still using them. These voluntary measures include the so-called Flemish panel in the Dover sole fishery, larger meshes, the pulse trawl (prior to 1 July 2021), and a different rigging of the bobbin rope.

Most respondents (87%) found it valuable to reduce catches of fish under minimum landing size. Of the four fishers who did not consider this valuable, two were also less inclined to voluntarily use selective measures, even if conditions were favourable (see next sections). On the question of which requirements more selective fishing techniques should meet, 50% of the fishers who responded to the survey prioritised "maintaining a healthy fish stock." This was followed by "catching fewer discards" (20%) and "net profit equal to the conventional gear" (20%). "Reduction in fuel use" was the least important criterion for more selective gear (10%).

Reasons for (lack of) voluntary uptake of proven gear

In the interviews, fishers identified the following benefits of more selective fishing: less processing time on board, improved labour conditions, cost reduction, and fish stock management: *"Everything we don't catch now, we can catch later when they are big enough. It supports the increase of the stock."* (Fisher B). They mentioned several reasons they themselves were reluctant to take-up proven gear. These included: investment costs; the regulatory framework that can be counterproductive or is too bureaucratic in (quickly) enabling use of proven gear; loss of commercial catch; lack of positive incentives (e.g. a reward system); and the lack of a level playing field. Illustrative is a remark by a fisher who considered the SepNep in the nephrops fishery to be a successful selectivity measure [significant discards reduction with marginal loss of target species], but who said: *"if I am the only one using it, there is no advantage, and there is no compensation for fishers who do make the choice to use it."* (Fisher C). A shrimp fisher who had voluntary used a larger mesh size said: *"You lose the smaller, yet still marketable shrimp. So, each week, you throw 3 000 euros overboard. I stopped with that. I landed a much better-quality product. My catch did not contain so many different sizes of shrimp anymore. But personally, I did not get any advantage from it, no reward at all."* (Fisher D). Many interviewees felt frustrated about European legislation, believed to hinder rather than to encourage selective fisheries. In this context, the ban on pulse fishing was regarded as a major setback in developing a more selective fishery; both directly, as the pulse gear was more selective and resulted in less benthic impact than the traditional gear (Rijnsdorp *et al.*, 2020), and indirectly, as it demotivated many fishers to continue working on innovations.

Fishers were also asked why they think their colleagues do not take-up proven fishing gear. They again highlighted investment costs and the counterproductive, bureaucratic regulatory framework. None of the interviewees mentioned the lack of a level playing field and loss of commercial catch. Additional factors believed to deter other fishers from adopting proven gear included reluctance to change; and demotivation because of disappointing policy developments, such as the landing obligation, the ban on pulse trawling and area closures. Industry representatives and most scientists considered the loss of commercial catch as the main factor for the lack of voluntary uptake of proven fishing gear. The government official echoed the fishers' observations that many Dutch fishers are less motivated to work on gear selectivity or adopt proven gears since the European decision to ban pulse trawling. All four interviewed groups emphasised that uptake of proven fishing gear required some form of regulation (see next section).

In the online survey, fishers were asked to respond to the interview findings on the reasons for lack of voluntary uptake. The 13 fishers who had indicated that they had never voluntarily adopted gear modifications developed by their peers were shown a number of statements describing possible reasons for not doing so. They were asked to select the three most important reasons that drove their decision (Table 3 [A]). We then asked all respondents (n = 30) the same question but now from the perspective of their colleagues (*Why do you think your colleagues do not voluntarily take up proven gear?*) (Table 3 [B]). They cited the loss of commercial catch (gross revenue loss) amongst the main reasons for lack of voluntary uptake; this factor is, however, relatively more often associated with what mattered for colleagues. Equally, the level playing field (*"don't do it, because colleagues don't do it"*) is more associated with what matters for peers. The associated investment costs of gear modifications were important in both cases. The number one reason for lack of voluntary uptake was demotivation caused by the ban on pulse fishing, which scored second for their beliefs about their peers' perspectives. Interestingly, no respondent considered "new techniques or modification are complicated to use" and "lack of motivation to try out modifications" as applying to themselves, while they did attribute this as considerations for their peers.

What is needed to encourage uptake of selectivity measures?

In the interviews, fishers proposed several motivators to encourage uptake of selectivity measures. The two most mentioned motivators were: (i) subsidies to cover investment costs or initial loss of revenue; and (ii) the need for a level playing field to be organised through regulations. These motivators were often linked to one another: *"Selective fishing always results in some loss of commercial catch. This is not a terrible thing, but it is a problem if you're the only one doing it. If everybody is doing it, there is no longer a loss."* (Fisher C). Another fisher (E) explained: *"You have to learn how to work with the new gear or modification. That's a disadvantage and is also related to your earnings."* Fisher A said: *"Financial support. [The selectivity measure] should be accessible for all. And if it really works well, it must be made compulsory. […] The rules have to be equal within each fishery type."* Fishers also indicated that the current regulatory system is driven too much by penalising fishers. They felt that, instead, fishers who voluntary adopt selectivity measures should be rewarded; they should receive advantages over colleagues who are reluctant to change; other suggestions included ad-

Table 3. Reasons why Dutch demersal fishers will not voluntarily be taking up proven gear: (A) own perspective and (B) beliefs about colleagues' perspectives. *Survey findings (n = 30); [A] only for fishers who indicated they did not voluntarily use proven gear (13); [B] question for all fishers (30); [A] + [B] maximum 3 choices; ranking by [A] highest to lowest scoring numbers.*

No voluntary uptake of proven selective gear, because of:	[A] Important for me	[B] What I think matters for my colleagues
Demotivated by the pulse ban	6	10
Loss of commercial catch resulting in loss of net revenue	4	16
Investment costs too large	3	4
Because colleagues do not use it (level playing field)	2	8
Discards reduction is not important	2	2
Other, namely (own choice): the policy and regulatory system	1	1
New techniques/modifications too complicated to use	0	3
Lack of motivation to try out modifications	0	2

ditional quota or the establishment of *"a credit system for fishers who do the right thing."* Fishers also considered improvement of information flows and in particular knowledge exchange and cooperation between colleagues, as took place in the Fisher Knowledge Networks, as a motivator: *"Once there were 3 fishers who each focussed on a different part of the net. Together they would have designed the perfect net. In order to make steps, we need groups of fishers working together instead of regarding each other as competitors."* (Fisher B). In this context, one fisher explicitly mentioned awareness-building for the next generations of fishers: *"Already at [the fisheries] school, they should teach that [discarding] is not a good thing. They need to be aware that it's better to let the smaller fish swim. This is important as part of corporate social responsibility. The fisher should not want to this [catch juveniles] himself anymore."* (Fisher F). Another fisher also pointed at the importance of the younger generation: *"We should focus on the next generation. […] People above 50 find it difficult to accept changes. The younger generation is much more prone to adapting to change."* (Fisher B). Fishers also considered greater flexibility in rules to be an important encouragement (see next section). In relation to the regulatory framework, they believed that revoking the decision to ban pulse fishing would have a significant positive impact on the drive to actively work on selectivity measures: *"The whole fleet feels stabbed in the back because of the pulse. Therefore, everybody is reluctant. We need positive motivation, because that creates a positive working atmosphere."* (Fisher E).

The industry representatives and scientists all shared the same opinion: the only way of encouraging uptake of proven fishing gear is by making its use mandatory (see next section for further discussion). Two scientists suggested that a reward system for voluntarily use of proven gear would encourage uptake, provided this system would provide real benefits over not using it. One scientist believed that voluntary uptake will only happen if the modification performs better economically (better catch, better profit). This scientist pointed to the importance of developing cost-benefit analyses in creating awareness amongst fishers and suggested fishers should be compensated for short term losses: *"[In the past] we developed economic and population dynamic models. In the beginning, introducing more selective gear will result in loss of income, but the models show that income will increase in time and stocks will grow. Projections were even that things would be better compared to status quo in 3–4 years" time. But to convince the fishers, they will need to be compensated to cover short term loss of income. Compare it to the current COVID-19 compensation for companies."* (Scientist 2).

In the survey, fishers who indicated they had not voluntarily taken-up proven fishing techniques (n = 13) were given a special question. They were asked what incentives would be needed for them to do so. They could select a maximum of two options. "Subsidies to cover investment costs" stood out as a key factor (9 scores). "Equal profits compared to the conventional gears" (4 scores) and "a reward system for voluntary use of more selective gears" (4 scores) followed. "Making its use mandatory" was selected three times. All respondents (n = 30) were then asked the same three questions in relation to incentives to voluntary use proven fishing gear. The first was about subsidies, the second about fuel reduction, and the third about level playing field. Most of the fishers (93%) indicated that subsidies for investment costs would result in their voluntary use of selective gear (i.e. no regulatory obligation). However, the conditions under which they would do so differed. Five of them would only do this if their commercial catch would be the same (no loss of gross revenue); 8 would only do it if the loss in gross revenue was marginal; and 13 would only do it if their net profit remained at least the same. Only one fisher commented that he was *"dead against subsidies."* The second question was whether fuel reduction would be an encouragement for voluntary uptake of more selective techniques. All respondents answered yes. But here also, different conditions apply: 50% would accept losses in commercial catch or gross revenue if this would be at least compensated by lower costs due to fuel reduction. In other words, if the net profit was higher, they would accept loss of commercial catch. Just over one quarter (26%) said it would depend on the duration of the return on investment together with the impact on net profit. For 24%, "no loss in commercial catch" was the only criterion that mattered.

Fishers were also asked to respond to the following statement: Would you choose to use a selectivity measure that would lead to some loss of commercial catch, if you knew for sure your colleagues would also use it?" 20 fishers answered yes; 10 would not do this. The willingness to do so was highest amongst the flatfish fishers. A fisher who was interviewed, said, in relation to this question: *"I would accept some loss of catch, but then it must be done through legislation. Everybody must be treated equally, without any exceptions. And it has to be enforceable as well."* (Fisher E). Others echoed this and stressed that this also applied to other countries: *"The same rules must apply irrespective of the country. This is currently not the case."* (Fisher G). The issue of the level playing field, where the same rules apply to the same type of métier, is closely related to the opinions about the regulatory framework in fisheries policy.

Regulations and voluntary uptake of selective fishing gear

The regulatory framework was a returning topic in all interviews. In all stakeholder groups, regulations in relation to selectivity uptake were referred to before any dedicated questions about the topic came up. Questions that triggered interviewees to mention the regulatory framework were related to involvement in selectivity research, voluntary use of proven fishing gear and solutions to encourage voluntary uptake. The regulatory system in general was felt to be too complex. This is partly due to the large number of exemptions that were granted every time a rule did not work for (part of) a fleet. Fishers, industry representatives and some scientists see a system with a large gap between the regulations and their feasibility in practice, and with an inclination to command and control: *"Brussel always comes up with the same medicine: stricter rules, more enforcement. That doesn't work. You have to start a dialogue with fishers to see what is and what isn't feasible in practice"* (Industry representative 1). The landing obligation was often mentioned as an example of an unworkable and non-enforceable regulation and hence a failing selectivity policy. In the survey (n = 30), the landing obligation was said by 83% of respondents not to have resulted in any changes in fishing practices. In the interviews, fishers, industry representatives and scientists were asked what changes would be needed in the regulatory system to encourage voluntary uptake of selectivity measures. The following criteria for an improved regulatory system emerged: "practically feasible," "simple," "enforceable," "flexible" and "tailored to the specific fishery." Fishers stressed the importance of rules that connected to practice: *"It is difficult to enforce a rule that does not make sense."* (Fisher F) and *"One-size-fits all measures don't work. […] Measures must be watertight and must really work. Otherwise compliance and enforcement are going to be difficult."* (Fisher C). In this context, one of the scientists suggested setting up a *"technical measures-free fishing pilot"*, where fishers get certain discard reduction targets and make their own plan how to achieve this. The fishing representatives considered further devolvement of management as part of the CFP's regionalisation approach and greater responsibility for the industry, to be the way forward to achieve a system with less rules that work and can be enforced. Representatives and fishers stressed that fisheries management should involve both parties, or as one of the fishers put it: *"Management measures have to come from both sides. It cannot only be from Brussels"* (Fisher E). Both fishers and scientists stressed the need for science-based management: *"Decisions should be based on scientific evidence instead of emotions."* (Fisher A). This call for science-based decision-making does not merely stem from perceptions about the events leading to the ban on pulse fishing (Kraan *et al.*, 2020), but also to incentives associated with the encouragement of selectivity improvements in current regulations: *"The regulations include measures that have never been really properly tested in a commercial fishery situation. An example is the Flemish panel [which gives beam-trawlers an exemption to the landing obligation for Dover sole."* (Scientist 1). This scientist also stressed the need to include standards on how new selectivity measures should be tested in the technical measures regulation. The latter suggestion relates not only to evidence-based management but also to a level playing field.

Achieving a level playing field with respect to the regulations was widely regarded as a prerequisite for encouraging more selective fishing practices. *"Only if a more selective gear leads to better net profits, [fishers] will pick it up voluntarily."* (Scientist 2). But because there is usually some revenue loss or investment costs involved, the predominant shared opinion amongst fishers, industry representatives and scientists was that uptake should be regulated to ensure the burden of loss is shared. Industry representatives gave a number of examples where they had requested the fisheries ministry make voluntary selectivity measures such as SepNep and the Flemish panel part of the mandatory regulations: *"Many of our members don't like that, but as a fishery association there is no other option."* (Industry representative 2). These requests were unsuccessful, as this (were it to apply to all North Sea fishers irrespective of country of registration) would require a revision of the European technical measures regulation, which takes years. However, both SepNep and the Flemish panel were included in the regional discards plan for the North Sea and voluntarily using them means a (temporary) exemption from the obligation to land respectively plaice and Dover sole below minimum landing size (VisNed, 2020). Operational uptake of these options is, however, limited. The SepNep is not used at all and the Flemish panel by an estimated 25% of the fleet (sources: scientist 1, industry representative 1). The interviewed government official explained that national fisheries organisations often have diverging opinions about incorporating selectivity measures in regulations, which deters political decision-making. In addition, making selectivity measures mandatory can initially only be done effectively at national level (application to one's own vessels only), as changing European legislation takes a lot of time. This means that many fishers are not in favour of this, as it would mean that different rules apply to them compared to fishers in the same métier flying the flag of a different Member State. As part of the level playing field, fishers, industry representatives, and scientist stressed the need for good enforcement. Many interviewees found current rules too complex to be properly enforced. This hinders moving towards more selective fisheries, as lack of enforcement creates room for evasive behaviour (*cf.* Catchpole *et al.*, 2008). But they all stressed that, in the end, rules only work if there is a well-operating control and enforcement system, with a high chance of being caught and heavy penalties for non-complying fishers. Two fishers and one industry representative added that the current system is rooted in the idea of penalising fishers and believed that a system were fishers are rewarded would be more productive. *"Reward us for letting the juveniles swim, for example by giving us additional quota or a credit system for things you do well instead of for things you do wrong."* (Fisher F).

The survey included a number of statements in relation to European regulations for selective fishing (Table 4). The responses indicated preference for a regulatory system that relies on fisher involvement in developing rules, has fewer rules and less prescriptive rules and gives more responsibility to industry. The level playing field and strong enforcement are also important aspects of the regulatory system. Although fishers found it reasonable to expect that, in return for more responsibility, the burden of proof should be with the fishers, almost a third would forego this opportunity if this meant the implementation of an on-board CCTV system. The survey also asked fishers' opinions about "co-management" (Wilson

Table 4. Opinions on European regulations on selective fishing. *Survey findings (n = 30); respondents were asked which of the below statement they agreed with most; maximum 3 choices possible; statements ordered as appeared in survey.*

Statement	Score
The European technical measures regulations are fine; keep them as they are.	0
The European technical measures regulations are fine, but better control and enforcement is needed	2
The European technical measures regulations are much too detailed (micromanagement) and are therefore unworkable.	14
The European technical measures regulations are too much based on the premise that all fisheries are the same and are therefore unworkable.	13
The European technical measures regulations should be made together with the fishing industry to create a workable environment.	17
There should be less technical measures coming from Europe with more responsibility placed at the fishers' level.	9
The control and enforcement of the European technical measures is the biggest problem.	3
As long as control and enforcement are not in order, the European technical measures regulations will never work well.	4
If more responsibility is given to the fishers, so that we can introduce selectivity measures ourselves, it is reasonable that Brussels expects us to prove that we are doing this the right way.	6
If we would get less rules from Brussels and we get more own responsibility, I would be willing to accept CCTV monitoring on board.	1
Less rules from Brussels and more own responsibility is needed, but not if this means I will get CCTV cameras on board.	9
I don't care who makes the rules, as long as they are the same for everybody and are enforced.	8

et al., 2003), based on a regulatory system that would devolve more responsibility for designing and implementing rules to fishers, under the explicit conditions that policy targets are being met and the rules developed by industry are being controlled. One third of the respondents (n = 30) were against a devolved management system. They believed fishers are incapable of carrying such own responsibility. One third favoured a devolved management system. However, amongst those in favour opinions on who is responsible for control and enforcement differed: the majority of this group (60%) felt that this would require strong enforcement by government; the other 40% would like such a system even if it meant the industry became responsible for enforcing it. The remaining one third did not know.

Survey respondents also suggested rewarding fishers who reduce unwanted by-catch. This suggestion was made both as part of an open-ended question about top-of-mind ideas to encourage more selective fishing (6 mentions) and a multiple-choice question visible only to 13 fishers who had not adopted more selective gear (4 mentions). Answers to an open-ended question on how to motivate fishers to fish more selectively showed a strong link to the regulatory system. In addition to introducing a reward system, the need for less complex rules, more flexibility in the regulations, and better control and enforcement came up as top-of-mind suggestions.

Discussion

Poor voluntary uptake of proven fishing gears has been linked to a variety of factors that can be clustered around three different aspects: (i) social (comprising cultural, historic, economic, and behavioural factors); (ii) policy; and (iii) science related. Our study confirms findings from scientific literature, but also found additional factors influencing voluntary uptake (Figure 1). It also challenges the assumption that a move from science-led towards industry-driven development of gear innovation will increase voluntary uptake of proven gear (Calderwood *et al.*, 2021; S. J. Kennelly & Broadhurst, 2002; Hall & Mainprize, 2005; ICES, 2018; Veiga-Malta *et al.*, 2019). Fisher-led gear development may contribute to bigger buy-in for the technical adaptations amongst peers, but voluntary uptake of proven gear requires more than that.

Six combined factors play a key role in dissuading Dutch fishers from voluntarily adopting more selective fishing gear: (i) loss of commercial catch resulting in gross revenue losses; (ii) investment costs; (iii) a "one size fits all," counterproductive or bureaucratic regulatory framework; (iv) a level playing field; (v) reluctance to change (referring to peers); and (vi) demotivation due to policy developments. These factors were derived from fishers' own perspectives as well as their beliefs about what matters most for their peers. We note that interviewees and survey respondents were mainly fishers with a clear interest in selective gears (see Methods), potentially introducing some bias. However, "commercial catch losses," "investment costs," and "resistance to change" have also been identified in other studies as being important contributors to the lack of uptake of proven gear (Graham *et al.*, 2007; Eayrs *et al.*, 2015; S. J. Hall & Mainprize, 2005; Jennings & Revill, 2007; Suuronen & Sardà, 2007; ICES, 2018). These studies, it is true, were mainly based on personal observations from their authors in the context of assessments on the contribution of gear technology to management or on impact evaluations of gear technology research, without actively asking fishers. Still taken together, they suggest that these aspects of voluntary gear uptake are more widely shared. The aspect "level playing field," where the same rules apply to all, was also highlighted in interviews with Irish fishers about technical modifications to increase gear selectivity (Calderwood *et al.*, 2021) and in studies in the context of the revision of the European fisheries technical measures policy (Kraan *et al.*, 2015). In these studies, the need for a level playing field was mainly discussed in the context of technical measures legislation and equal application between Member States, and not in relation to voluntary uptake of proven fishing gears and between fishers sharing the same nationality and métier, but again, this indicates that these concerns are not new. Contrary to other studies, science-related factors and lack of technical knowledge as a social aspect were not found to be linked to low uptake amongst Dutch fishers. This is perhaps not a surprise considering the history of science-industry research collaboration in the Netherlands with strong involvement of fishers and a focus on knowledge exchange and communication (de Vos & Mol, 2010; Steins *et al.*, 2020; van Hoof *et al.*, 2020; de Boois *et al.*, 2021).

Our study suggests that the different factors influencing fishers' choices to voluntary adopt proven fishing gear can be linked to both their "Willingness" and "Ability" to change. Figure 1 shows a schematic overview of how the social, policy- and science-related factors associated with volun-

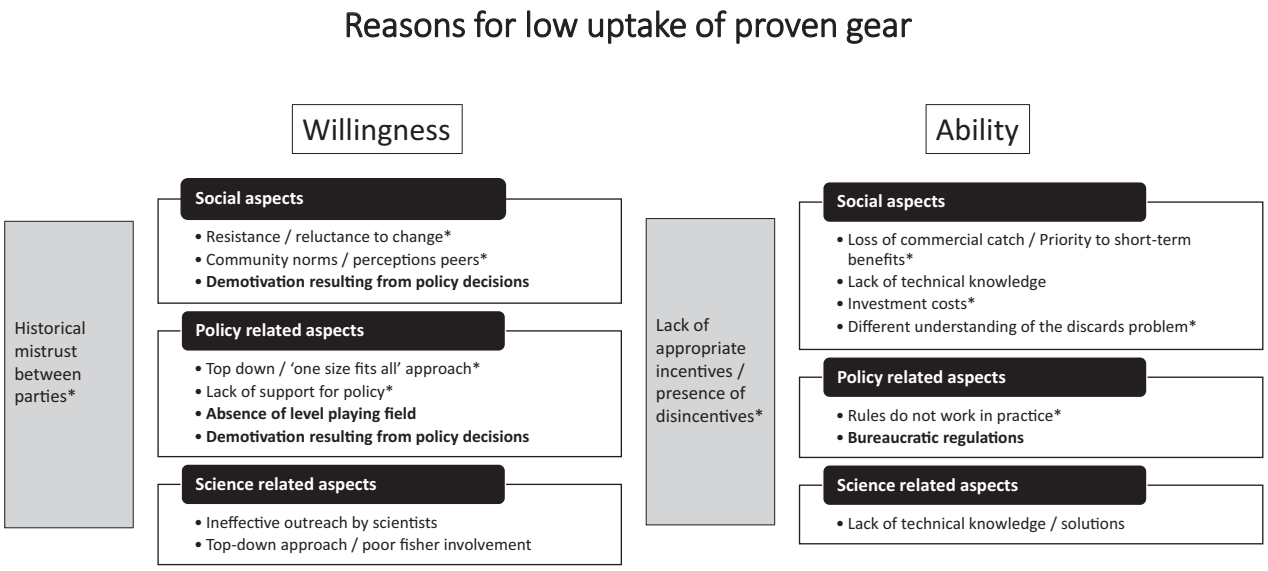

Figure 1. Schematic overview of factors associated with low uptake of proven fishing gear. *Organised by aspects linked to Willingness and Ability. The two grey boxes indicate factors that span over social, policy- and science-related aspects. Sources (except for bold: this study):* Barz *et al.*, 2020; Calderwood *et al.*, 2021; Eayrs *et al.*, 2015; Eayrs & Pol, 2019; Graham *et al.*, 2007; S. J. Hall & Mainprize, 2005; ICES, 2018; Jennings & Revill, 2007; Kennelly & Broadhurst, 2002; Kraan *et al.*, 2015; Penas Lado, 2016; Suuronen & Gilman, 2020; Suuronen & Sardà, 2007; Veiga-Malta *et al.*, 2019. ∗*From literature sources, and also found for Dutch fishers in this study. Bold: Found in this study (Dutch fishers).*

tary uptake can be attributed to these two behavioural components. Willingness is closely linked to intrinsic motivations and beliefs about sustainable fishing, as well as perceptions about the motivations and behaviour of other fishers (own crew, colleagues). It is also associated with the extent to which policy and measures fit in a fisher's belief system (Verweij *et al.*, 2010), i.e. are perceived as legitimate. If a policy target or management measure does not make sense for the fishers, they will be less willing to work towards achieving it (Eliasen *et al.*, 2014; Kraan & Verweij, 2020). An example is the European landing obligation, aimed at encouraging selective fishing, which has been debated by industry from the start (Villasante *et al.*, 2018; Fauconnet *et al.*, 2019; Kraan & Verweij, 2020). Dutch fishers, for instance, question negative influences of discarding on stock size, as they experience healthy target stocks in a system of discarding; also they argue that landing all undersized fish will lead to increased fish mortality and loss of nutrients to the ecosystem, which will affect stocks and result in increasing costs for fishers (Kraan & Verweij, 2020). These perceptions of "the discards problem" influence their intrinsic motivations and, linked to the expected costs of the landing obligation (Ability: financially and socially) has made them reluctant to "come on board." Their lack of engagement and support is illustrated by the fishing industry's focus on getting exemptions to the landing obligation and findings of widespread non-compliance (ECFA, 2020). Our research indicates that, in general, Dutch fishers strongly support the idea to reduce catches of fish under minimum landing size, i.e. they are willing to work towards more selective fishing. But, unless there are strong economic benefits from voluntary using selectivity measures (pulse trawl), adopting selectivity measures must meet fishers' perceptions of a legitimate regulatory framework (Willingness: level playing field) and should be facilitated (Ability: financial, technical, regulatory). As selectivity measures usually result in (short or medium term) losses, the adoption of proven fishing gear *de facto* calls for a regulatory approach to establish the desired level playing field, where the same rules apply and are enforced within métiers at both the national and international level (*cf.* Calderwood *et al.*, 2021). This call for regulations by fishers seems paradoxical given that the European technical measures regulations are considered to be too complex and seen as an example of top-down micromanagement by fishers, representatives, policy-makers, and other stakeholders (Kraan *et al.*, 2015; Penas Lado, 2016). However, rather than adding regulations to the current technical measures framework, our study findings suggest exploring alternative regulatory approaches. These are based on enabling and rewarding, and address both "Willingness" and "Ability" as behavioural components of voluntary gear uptake (Figure 1).

Ability, our study shows, is associated with knowledge, skills, economic, and legal possibilities to enable voluntary uptake. Enabling relates to providing fishers with opportunities to develop and adopt proven fishing gear. One regulatory option addressing Ability that could be considered is providing temporary transition grants to account for short-term economic losses associated with using more selective gear. Reduced profits due to loss of catch means less income, which is a particular concern for fishing companies operating with a share system. This affects the skipper and crew's motivation to experiment with gear modifications and impairs further development as well as uptake of proven gears. In lean years, fishers will even be less inclined to do so as sticking to the conventional gear will result in a better economic position. Short-term economic losses affecting income have been known to result in fishers ignoring, sabotaging or making little effort to implement mandatory technical measures effectively (Catchpole *et al.*, 2008; S. J. Hall & Mainprize, 2005; Suuronen & Sardà, 2007; Penas Lado, 2016). The provision of temporary transition grants covering short-term losses may therefore facilitate its effective implementation. In the European context, regulations in relation to state aid may be an inhibiting fac-

tor for this enabling financial mechanism and may have to be adapted. Enabling through financial assistance could also be directed at subsidising part of the investment costs for gear innovations. In the European Union, this is possible under strict conditions and under the condition such innovations contribute to sustainable fisheries. This option may, however, be challenged as in the policy arena there are different narratives on sustainable fisheries and innovations and facilitating these through subsidies (Sumaila *et al.*, 2010; Le Manach *et al.*, 2019; Kraan *et al.*, 2020).

An enabler that addresses both Ability and Willingness is encouraging knowledge exchange. Interviewees emphasized the importance of working together, so that gear development can benefit from the expertise of different fishers. Indeed, the cross-community Fisher Knowledge Networks, as part of the Dutch fisheries innovation agenda in the period 2007–2016, were key in accelerating fisheries innovation and building trust relations between fishers (de Vos & Mol, 2010; Quirijns *et al.*, 2019; van Hoof *et al.*, 2020). Unfortunately, funding for the Networks ended with revised Dutch grant innovation policies. Under these new policies, knowledge exchange and communication had to become part of large fisheries innovation projects. As a result, gear innovation once more became "regional business" instead of national cross-community collaborations and again largely driven by fisheries associations, with different agendas and low levels of mutual trust. Promoting Fisher Knowledge Networks or a similar structure would provide additional facilitating enablers for developing gear adaptations (Quirijns *et al.*, 2019). Enabling also involves education about sustainable stock management and fishing gear impacts (*cf.* Catchpole *et al.*, 2008) as well as making information about gear adaptation projects and their results available to the whole fleet, including the new generation at the fishing schools.

Rewards are an alternative option as part of regulatory approaches to encourage voluntary uptake of proven fishing gear. Rewards can be direct and tangible (e.g. lower costs) or indirect (e.g. access to areas that are closed to others), and often work interdependently. For new practices to become a habit (or a social norm), adjusting to new behaviour is needed. This requires that new practices are perceived as an improvement (and thus rewarding). Whether or not a new practice is seen as rewarding is not only related to direct costs or workload (Ability), but often depends on other factors such as compliance with or enforcement of rules and perceptions of policy. A clear finding from our study is that Willingness to voluntarily adopt proven gear is strongly linked to fishers' perceptions of legitimacy and credibility of the CFP and specific measures, such as the landing obligation. Understanding different perceptions and lines of reasoning behind policy measures by fishers and policy-makers and discussing these explicitly contributes towards shared definitions of policy objectives and shared understanding of (un)intended effects. This facilitates a more cooperative implementation environment for more selective fisheries (Steins & Edwards, 1999; Verweij *et al.*, 2010; Kraan & Verweij, 2020). A policy system that is responsive to these perceptions and fishers' ideas is likely to be more effective in appealing to Willingness as a behavioural component and, hence fishers' motivation to change. The introduction of more responsive system was attempted with the "regionalisation approach" under the current CFP (Eliasen *et al.*, 2015; Nielsen *et al.*, 2015; Penas Lado, 2016). The CFP's system of "command and control" (Penas Lado, 2016) has, however, not changed as a result of regionalisation. Policy and regulations still lean heavily on penalising fishers for non-compliance rather than rewarding them. Proving non-compliance, i.e. catching fishers involved in illegal activities at sea, is, however, extremely difficult. This situation creates room for evading the rules and strengthens feelings of distrust amongst fishers themselves and between different stakeholders. Penalising is, however, not limited to sanctioning. The findings from our case study suggest that fishers have a broader definition of penalising. Penalising also means having to work in a restrictive regulatory environment with rules that make no sense to them (and thereby lack legitimacy). This acts as a perverse incentive for working towards more selective fisheries (Willingness). The interviewees suggested introducing a reward system to incentivise voluntary uptake of proven fishing gear. The idea was explored in the survey, where it ranked second in proposed enablers of voluntary uptake.

A reward system has implicitly been introduced as part of the landing obligation. Under certain conditions, fishers can get an exemption (Anon., 2013). An example is the use of the Flemish panel, which grants an exemption for Dover sole in the beam-trawl fishery. It is estimated that only about 25% of the Dutch fleet is using this escape panel (source: fisheries representative 1). The incentive to voluntarily use the Flemish panel and be rewarded with an exemption is low as the panel results in potential loss of valuable marketable sized sole, by-catch of smaller length categories of undersized juvenile soles are low anyway, and the landing obligation is (European-wide) poorly enforced (ECFA, 2020). As such, use of the Flemish panel can hardly be seen as a reward, which affects their Willingness to use it. For a reward to work as an incentive to voluntary adopt selectivity measures (or indeed other measures), it has to offer clear and tangible benefits over those who are not using it. Although fishers in our case study made suggestions for rewards, such as additional quota allocations or the introduction of a credit system, we did not explore potential rewards and how effective fishers anticipated these would be. Introducing rewards, such as "nudges based on social norms" (Mackay *et al.*, 2021), credit systems or real-time incentive systems (and combinations thereof) have, laboratory and model studies suggest, the potential to incentivise fishers (Kraak *et al.*, 2012, 2015; Mackay *et al.*, 2021; Pedreschi *et al.*, 2021; Van Riel *et al.*, 2015). Further field studies, actively involving fishers, into how a reward system could be designed to effectively encourage voluntary uptake of proven gear or indeed other management measures are recommended.

Introducing enablers and rewards as incentives for voluntary uptake of proven gear is an alternative way forward towards more selective fisheries, particularly when there are no strong immediate benefits of the innovation. It addresses both fishers' Ability and Willingness to change. More incentive-based management calls heavily upon fishers' own responsibility as a driver, and would require a further move towards co-management (Nielsen *et al.*, 2015; Wilson *et al.*, 2003) or fisher-directed management (Hart, 2021). Taking this responsibility seems at odds with the current top-down, prescriptive regulatory framework in Europe. As part of the regionalisation approach, some steps have been taken towards more results-based management in relation to technical conservation measures (EC, 2021). However, giving a more active role to Member States in developing fisheries management plans does not seem to have resulted in a more inclusive approach, that actively involves the fishing industry in developing and

achieving management targets (Eliasen *et al.*, 2015). A real policy shift from input-based management to results-based management (Nielsen *et al.*, 2015, 2018) would open up opportunities for an incentive-based approach to more selective fisheries, including flexibility in management rules and rules based on both technical and tactical measures (Barz *et al.*, 2020; Calderwood *et al.*, 2021), connecting better to operational fishing practices. This presumably leads to better compliance. The survey results indicate support amongst Dutch fishers for results-based co-management (Table 4). They have positive experiences with such a system: European quota allocations at national level have been successfully managed through a co-management system since 1993 following years of non-compliance (Hoefnagel & de Vos, 2017; van Hoof *et al.*, 2020). Our research suggests, however, that whilst fishers feel they should be involved in designing regulations that work in practice (simple, tailored to the fishery), they have mixed feelings about giving the fishing industry greater responsibilities in operational management; fishers question their ability to carry the responsibility (*cf.* Catchpole *et al.*, 2008). Even within the group of fishers who favour devolved management, the majority indicate this would require strong enforcement by government. Indeed, survey results indicate that good enforcement is a cornerstone of the functioning of conservation regulations, including selectivity measures (Table 4). Fishers' mixed feelings about where responsibilities should lie in a co-management system are rooted in trust issues (*cf.* Catchpole *et al.*, 2008; Ford & Stewart, 2021; Nielsen *et al.*, 2018; Penas Lado, 2016). This trust issue may be linked to the lack of unity amongst fishers, their representatives and associations with respect to the current Dutch marine spatial planning process (Koning *et al.*, 2021; Steins *et al.*, 2021). Trust goes beyond national level. Trust in other fishers' behaviour (*cf.* Catchpole *et al.*, 2008; Yandle *et al.*, 2011) and a strong normative belief that the same rules should apply to all engaged in the same fishery or métier (*cf.* Calderwood *et al.*, 2021), ironically seem to result in maintaining the status quo of a bureaucratic command and control situation that the introduction of the regionalisation approach in the CFP tried to address: "In the absence of trust among the actors [among Member States, between national administrations and industry, and among European institutions], the general response will be to try to specify the rules as precisely as possible in order to ensure that nobody abuses the system." (Penas Lado, 2016).

Technological advances, such as "electronic monitoring" (Van Helmond *et al.*, 2019), offer opportunities to more results-based management. For example, a comprehensive review of electronic monitoring showed that its data can be used to inform fishers about temporal and spatial distribution of juveniles as part of avoidance practices, and for assessing performance of gear selectivity improvements. It could also serve as an alternative to full catch documentation under the landing obligation. The review also showed that incentives, such as increased flexibility in gear choice, individual quota uplifts and access to closed areas, could contribute to support for electronic monitoring amongst fishers (Van Helmond *et al.*, 2019). Support for electronic monitoring within the European fishing industry, however, is low (Ford & Stewart, 2021; Van Helmond *et al.*, 2019). These low levels of support are further reduced by the current framing by the European Commission, European Parliament and NGOs of electronic monitoring as a CCTV compliance mechanism (EC, 2018; EP, 2021; EU Fisheries Control Coalition, 2021). Our survey results show that about a third of the respondents would forego a results-based co-management system if this means onboard CCTV cameras must be installed. Using electronic monitoring as an enabler for more results-based co-management will only be feasible with industry support (*cf.* Van Helmond *et al.*, 2019). This will be unlikely if camera use is promoted as a tool to constantly monitor compliance. Results-based co-management requires trust and "constant monitoring may […] be ineffective in promoting trust, as fishers feel victimised" (Ford & Stewart, 2021). While fisher-led and other collaborative research approaches foster the development of a trust relationship between fishers and scientists (de Boois *et al.*, 2021; Hartley & Robertson, 2011; Steins *et al.*, 2020), poor levels of trust amongst the different stakeholders involved in the regulatory framework inhibit movement towards alternative governance approaches. Explicit attention for addressing Willingness as a behavioural component will be required when introducing rewards and enablers in this context. This includes dialogue towards a shared understanding and definition of policy goals (Kraan & Verweij, 2020) and full consideration of trust issues (Ford & Stewart, 2021).

Finally, in the context of incentivising fishers through rewarding and enabling, as well as trust issues in regulatory frameworks, it is also important to consider unintended impacts of policy decisions. Specifically, in our case study, the impact of the ban on pulse trawling on the innovation climate is relevant. In interviews and the survey, the pulse trawl was named as one of the proven selectivity measures fishers had adopted voluntary. The gear, which was being developed under a derogation clause in European legislation (enabling), resulted in strong economic benefits as a result of increased selectivity for Dover sole combined with significantly less fuel costs from reduced drag. This caused a push for more licenses to enable more fishers to make the transition, which were granted as part of European policy processes (Haasnoot *et al.*, 2016). As scientific research demonstrated, compared to the traditional beam-trawl, the pulse trawl resulted in a more selective fishery, with significantly less benthic impacts, no adverse ecosystem impacts and significant CO_2-reduction (ICES, 2020; Rijnsdorp *et al.*, 2020). However, in 2019, a co-decision by the European Parliament, Council and Commission resulted in a ban pulse trawling, following an NGO campaign (Kraan *et al.*, 2020). This decision led to a general feeling within the Dutch fleet that, rather than being rewarded, they are being penalised for working very hard on a successful gear innovation towards a more sustainable fishery. This was also reflected in the interviews, where respondents from the fishing and scientific community indicated that revoking the decision to ban pulse fishing would significantly contribute to voluntary uptake of selective fishing techniques. The ban on pulse fishing was as a major demotivator impacting Ability (financial) and Willingness (motivation) to further engage in gear innovation development or related research, including cooperation in our survey (see Methods). The authors understood from colleagues in other institutes in north western Europe that, following the pulse ban, fishers in their countries also have questioned why they should invest in the development of innovative gears if in the policy process anything can happen. Similar observations were made in the case of bycatch reduction projects in Hawaii (M. A. Hall *et al.*, 2007). In the interviews, the need for an evidence-based approach to gear innovation was highlighted by fishers and scientists alike. The particular example of the pulse trawl reemphasises previ-

ous calls for the implementation of a "fishing gear innovation framework [to] provide a systematic approach to either rejecting or accepting a fishing gear innovation within the EU" (Haasnoot *et al.*, 2016). Such an innovation framework would need to address the level playing field fishers call for, perceived legitimacy of decisions and trust issues (Willingness). It is also relevant in the context of granting exemptions under the landing obligation, because currently, scientific standards to determine what defines a proven selectivity measure are lacking.

Conclusion

Many proven selective fishing gears are never put into practice. Although moving from science-led to fisher-led development of selective fishing gear is seen as way forward in improving voluntary uptake, we showed that this is not necessarily the case. Voluntary uptake of proven fishing gear is the result of a complex interplay of social, policy- and science-related factors. These can be linked to two behavioural components: Willingness and Ability. Policy approaches and the scientific literature tend to focus strongly on Ability as an enabling driver for increased voluntary uptake of proven gears. They do so by addressing disincentives or creating incentives to desired behaviour, such as cost reduction, financial support, introduction of simpler and more flexible regulations, individual quota uplifts or access to closed areas. These are indeed incentives fishers and their representatives often demand, as our study confirmed. However, focussing on Ability as a driver for encouraging selective fishing is unlikely to result in real changes without addressing social, policy- and science-related factors associated with Willingness. Our study showed that Willingness is closely linked to intrinsic motivations and beliefs about sustainable fishing as well as perceptions about the motivations and behaviour of other fishers. Willingness also has strong links to the extent to which fishers consider policy goals and regulations as legitimate. Furthermore, Willingness is associated to strong normative beliefs amongst fishers about the presence (or absence) of a level playing field, in terms of the same rules applying to all as well as trust in compliance and enforcement. In this context, the call for a regulatory approach to organize (voluntary) uptake of proven fishing gear by Dutch fishers is not paradoxical.

We recommend a stronger emphasis on Willingness as a behavioural component in encouraging more selective fisheries. This includes a policy and science focus on understanding perceptions of fishers, scientists, policy-makers and other actors involved about "the discards problem," understanding and acknowledging trust issues, and dialogue towards a shared definition of policy goals and potential solutions. From a European policy perspective, it will also require Willingness to use the potential of the CFP's regionalisation approach to shift from the current "command and control"-oriented framework towards results-based management. The development of a fisheries innovation framework in collaboration with all stakeholders will likely contribute positively to fishers' Willingness to work towards and adopt more selective fishing practices, as such a framework addresses legitimacy questions, including the level playing field. As part of such an innovation framework and further steps towards results-based management, exploring reward systems that offer clear and tangible benefits for fishers who are engaged in selective gear development or voluntarily adopt proven gears requires urgent attention. This includes scientists developing pilot projects together with fishers to explore the impact of introducing reward systems on changing behaviour in relation to more selective fisheries. It also requires a different narrative on electronic monitoring as a supporting tool for results-based management. Science also has a role in encouraging more selective fisheries. The literature on fishing gear technology including associated change management lacks studies that explicitly focus on fishers' motivations to take-up proven fishing gear. Addressing this gap is an important future research avenue as part of developing results-based management approaches towards more selective fisheries. Our schematic overview (Figure 1) that links social, policy and science related aspects influencing uptake to Willingness and Ability provides a basis for the development of conceptual framework to assist such future research.

Data availability statement

Interview summaries and survey results (all in Dutch) are available from the corresponding author, upon reasonable request, and under condition that all names are anonymized.

Supplementary data

Supplementary material is available at the *ICESJMS* online version of the manuscript.

Conflict of interest declaration

The authors have no conflict of interest to declare.

Acknowledgements

Our thanks go to all fishers, the industry and government representatives, and our colleagues who have participated in the interviews. We also thank the fishers who responded to the survey, and VisNed, Nederlandse Vissersbond and EMK for distributing it. Linda McPhee provided valuable editorial comments. Colleague Pieke Molenaar assisted in the selection of fishers for the interviews. Bob van Marlen reviewed the paragraph on historic developments in gear technology research. We also thank the three anonymous reviewers for their valuable comments.

References

Anon. 1989. World symposium on fishing gear and fishing vessel design, 1988. In World Symposium on Fishing Gear and Fishing Vessel Design, 1988 (Newfoundland and Labrador Institute of Fisheries and Marine Technology FAO International Council for the Exploration of the Sea Massachusetts Institute of Technology). St. Johns, Canada: Marine Institute.

Anon. 2013. Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC. Official Journal of the European Union, L 354/22. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013R1380&from=EN.

Anon. 2019. Regulation (EU) 2019/1241 of the European Parliament and of the Council of 20 June 2019 on the conservation of fisheries resources and the protection of marine ecosystems through technical measures, amending Council Regulations (EC) No 1967/2006, (EC) No. Official Journal of the European Union, L 198/105(25

July 2019), 97. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R1241&from=EN
Barz, F., Eckardt, J., Meyer, S., Kraak, S. B. M., and Strehlow, H. V. 2020. `Boats don't fish, people do' – How fishers' agency can inform fisheries-management on bycatch mitigation of marine mammals and sea birds. Marine Policy, 122: 104268.
Calderwood, J., Pedreschi, D., and Reid, D. G. 2021. Technical and tactical measures to reduce unwanted catches in mixed fisheries: do the opinions of irish fishers align with management advice? Marine Policy, 123: 104290.
Catchpole, T., van Keeken, O., Gray, T., and Piet, G. 2008. The discard problem – A comparative analysis of two fisheries: the English nephrops fishery and the Dutch beam trawl fishery. Ocean and Coastal Management, 51: 772–778.
de Boois, I. J., Steins, N. A., Quirijns, F. J., and Kraan, M. 2021. The compatibility of fishers and scientific surveys: increasing legitimacy without jeopardizing credibility. ICES Journal of Marine Science, 78: 1769–1780.
de Vos, B. I., and Mol, A. P. J. 2010. Changing trust relations within the Dutch fishing industry: the case of national study groups. Marine Policy, 34: 887–895.
Dinklo, I. 2006. Fabels en feiten over kwalitatieve onderzoeksresultaten hardnekkige misverstanden over generaliseren van kwalitatieve. KWALON, 32: 35–43. https://www.tijdschriftkwalon.nl/inhoud/tijdschrift_artikel/KW-11-2-10/Fabels-en-feiten-over-kwalitatieve-onderzoeksresultaten.
Eayrs, S., Cadrin, S. X., and Glass, C. W. 2015. Managing change in fisheries: a missing key to fishery-dependent data collection? ICES Journal of Marine Science, 72: 1152–1158.
Eayrs, S., and Pol, M. 2019. The myth of voluntary uptake of proven fishing gear: investigations into the challenges inspiring change in fisheries. ICES Journal of Marine Science, 76: 392–401.
EC. 2018. Proposal for a Regulation of the European Parliament and of the Council amending Council Regulation (EC) No 1224/2009, and amending Council Regulations (EC) No 768/2005, (EC) No 1967/2006, (EC) No 1005/2008, and Regulation (EU) No 2016/1139 of the Europea. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52018PC0368.
EC. 2021. Report from the Commission to the European Parliament and the Council: Implementation of the Technical Measures Regulation (Article 31 of Regulation (EU) 2019/1241). In SWD(2021) 268 final. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0583&from=EN.
ECFA. 2020. Evaluation suggests non-compliance with the landing obligations in certain fisheries in the North Sea and North Western Waters. European fisheries control agency (Webpage). https://www.efca.europa.eu/en/content/pressroom/evaluation-suggests-non-compliance-landing-obligations-certain-fisheries-north-sea
Eliasen, S. Q., Hegland, T. J., and Raakjær, J. 2015. Decentralising: the implementation of regionalisation and co-management under the post-2013 Common Fisheries Policy. Marine Policy, 62: 224–232.
Eliasen, S. Q., Papadopoulou, K.-N., Vassilopoulou, V., and Catchpole, T. L. 2014. Socio-economic and institutional incentives influencing fishers' behaviour in relation to fishing practices and discard. ICES Journal of Marine Science, 71: 1298–1307.
EP. 2021. Fishing rules: compulsory CCTV for certain vessels to counter infractions. Press Release European Parliament. https://www.europarl.europa.eu/news/en/press-room/20210304IPR99227/fishing-rules-compulsory-cctv-for-certain-vessels-to-counter-infractions.
EU Fisheries Control Coalition. 2021. Joint statement to EU ministers ahead of June 2021 AGRIFISH Council: 52 organisations worldwide urge EU Member States to combat illegal and unsustainable fishing practices: "Require cameras also on vessels below 24 metres." http://www.transparentfisheries.org/our-work/remote-electronic-monitoring/.
FAO. 2011. International guidelines on bycatch management and reduction of discards. Food and Agricultural Organization.Rome
Fauconnet, L., Frangoudes, K., Morato, T., Afonso, P., and Pita, C. 2019. Small-scale fishers' perception of the implementation of the EU landing obligation regulation in the outermost region of the azores. Journal of Environmental Management, 249: 109335.
Ford, E., and Stewart, B. D. 2021. Searching for a bridge over troubled waters: an exploratory analysis of trust in United Kingdom fisheries management. Marine Policy, 132: 104686.
Graham, N., Ferro, R. S. T., Karp, W. A., and MacMullen, P. 2007. Fishing practice, gear design, and the ecosystem approach – Three case studies demonstrating the effect of management strategy on gear selectivity and discards. ICES Journal of Marine Science, 64: 744–750.
Haasnoot, T., Kraan, M., and Bush, S. R. 2016. Fishing gear transitions: lessons from the Dutch flatfish pulse trawl. ICES Journal of Marine Science, 73: 1235–1243.
Hall, M. A., Nakano, H., Clarke, S., Thomas, S., Molloy, J., Peckham, S. H., Laudino-Santillán, J. *et al.* 2007. Working with fishers to reduce by-catches. In S. J. Kennelly (Ed.), By-catch reduction on the world's fisheries(pp. 235–289). Springer.
Hall, S. J., and Mainprize, B. M. 2005. Managing by-catch and discards: how much progress are we making and how can we do better? Fish and Fisheries, 6: 134–155.
Hart, P. J. B. 2021. Stewards of the sea: giving power to fishers. Marine Policy, 126: 104421.
Hartley, T. W., and Robertson, R. A. 2011. Cooperative research program goals in new england: perceptions of active commercial fishermen,. Fisheries, 33: 551–559.
Hoefnagel, E., and de Vos, B. 2017. Social and economic consequences of 40 years of Dutch quota management. Marine Policy, 80: 81–87.
ICES. 2018. Report of the workshop on methods for stakeholder involvement in gear development (WKMSIGD), 22-24 May 2018, BSAC and ICES HQ, Copenhagen. International Council for the Exploration of the Sea, CM 2018/EOSG:24. https://doi.org/10.17895/ices.pub.8179.
ICES. 2020. Request from The Netherlands regarding the impacts of pulse trawling on the ecosystem and environment from the sole (Solea solea) fishery in the north sea. In ICES Special Request Advice Greater North Sea Region (ICES Advic, Issue 20 May, pp. 1–12). International Council for the Exploration of the Sea. https://doi.org/10.17895/ices.advice.6020.
ICES. 2021. ICES – FAO Working group on fishing technology and fish behaviour (WGFTFB; outputs from 2020 meeting(D. Stepputtis, A. Sala, and P. He (eds.)). ICES Scientific Reports. 03:27. https://doi.org/10.17895/ices.pub.8022.
Jennings, S., and Revill, A. S. 2007. The role of gear technologists in supporting an ecosystem approach to fisheries. ICES Journal of Marine Science, 64: 1525–1534.
Kennelly, S. J. 2007. By-catch reduction in the world's fisheries. Springer.Dordrecht
Kennelly, S. J., and Broadhurst, M. K. 2002. By-catch begone: changes in the philosophy of fishing technology. Fish and Fisheries, 3: 340–355.
Koning, S. de, Steins, N. A., and Hoof, L. van. 2021. Balancing sustainability transitions through state-led participatory processes: the case of the Dutch North Sea Agreement. Sustainability, 13: 1–16.
Kraak, S. B. M., Reid, D. G., Bal, G., Barkai, A., Codling, E. A., Kelly, C. J., and Rogan, E. 2015. RTI ("Real-Time incentives") outperforms traditional management in a simulated mixed fishery and cases incorporating protection of vulnerable species and areas. Fisheries Research, 172: 209–224.
Kraak, S. B. M., Reid, D. G., Gerritsen, H. D., Kelly, C. J., Fitzpatrick, M., Codling, E. A., and Rogan, E. 2012. 21st century fisheries management: a spatio-temporally explicit tariff-based approach combining multiple drivers and incentivising responsible fishing. ICES Journal of Marine Science, 69: 590–601.
Kraan, M., Groeneveld, R., Pauwelussen, A., Haasnoot, T., and Bush, S. R. 2020. Science, subsidies and the politics of the pulse trawl ban in the European Union. Marine Policy, 118: 103975.
Kraan, M., Verkempynck, R., and Steins, N. A. 2015. Technical measures in the Atlantic and the North Sea: working with stakeholders towards meaningful revision. Report

for a workshop organised by the European Parliament Committee for Fisheries. European Parliament, IP/B/PECH/IC/2015-138. https://www.europarl.europa.eu/RegData/etudes/STUD/2015/563403/IPOL_STU(2015)563403_EN.pdf.

Kraan, M., and Verweij, M. 2020. Implementing the landing obligation: an analysis of the gap between fishers and policy-makers in The Netherlands. In P. Holm, M. Hadjimichael, S. Linke, and S. Mackinson Collaborative research in fisheries: Co-creating knowledge for fisheries knowledge in Europa(pp. 231–248). Springer. Cham.

Le Manach, F., Bisiaux, L., Villasante, S., and Nouvian, C. 2019. Public subsidies have supported the development of electric trawling in Europe. Marine Policy, 104: 225–231.

Mackay, M., Yamazaki, S., Jennings, S., Sibly, H., van Putten, I. E., and Emery, T. J. 2021. The influence of nudges on compliance behaviour in recreational fisheries: a laboratory experiment. ICES Journal of Marine Science, 77: 2319–2332.

Molenaar, P., Steenbergen, J., Glorius, S. T., and Dammers, M. 2016. Vermindering discards door netinnovatie in de noorse kreeft visserij. IMARES WageningenUR Rapport C027/16. https://edepot.wur.nl/376260.

Mortensen, L. O., Ulrich, C., Eliasen, S., and Olesen, H. J. 2017. Reducing discards without reducing profit: free gear choice in a danish result-based management trial. ICES Journal of Marine Science, 74: 1469–1479.

Nielsen, K. N., Aschan, M. M., Agnarsson, S., Ballesteros, M., Baudron, A., Borges, M. de F., Campos, A. *et al.* 2018. A framework for results-based management in fisheries. Fish and Fisheries, 19: 363–376.

Nielsen, K. N., Holm, P., and Aschan, M. 2015. Results based management in fisheries: delegating responsibility to resource users. Marine Policy, 51: 442–451.

Nooij, A. T. J. 1990. Normatieve en beschrijvende methodiek in grondvormen. Stenfert Kroese Uitgevers. Leiden

Pedreschi, D., Vigier, A., Höffle, H., Kraak, S. B. M., and Reid, D. G. 2021. Innovation through consultation: stakeholder perceptions of a novel fisheries management system reveal flexible approach to solving fisheries challenges. Marine Policy, 124: 104337.

Penas Lado, E. 2016. The Common Fisheries Policy: The quest for sustainability. Wiley-Blackwell. Chichester http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1119085640.html.

Quirijns, F. J., Steins, N. A., Zaalmink, B. W., Mol, A., Kraan, M. L., Strietman, W. J., Van Asseldonk, M. A. P. M. *et al.* 2019. Duurzame noordzee kottervisserij in ontwikkeling. Wageningen Marine Research report C085/19. https://doi.org/10.18174/499389.

Rijnsdorp, A. A. D., Boute, P., Tiano, J., Lankheet, M., Soetaert, K., Beier, U., De Borger, E. *et al.* 2020. The implications of a transition from tickler chain beam trawl to electric pulse trawl on the sustainability and ecosystem effects of the fishery for North Sea sole : an impact assessment. Wageningen Marine Research report C037/20. https://doi.org/https://doi.org/10.18174/519729.

Schadeberg, A., Kraan, M., and Hamon, K. 2021. Beyond métiers: social factors influencing fisher behaviour. ICES Journal of Marine Science, 78: 1530–1541.

Steins, N. A., and Edwards, V. M. 1999. Platforms for collective action in multiple-use common-pool resources. Agriculture and Human Values, 16: 241–255.

Steins, N. A., Kraan, M. L., van der Reijden, K. J., Quirijns, F. J., van 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.

Steins, N. A., Veraart, J. A., Klostermann, J. E. M., and Poelman, M. 2021. Combining offshore wind farms, nature conservation and seafood: lessons from a dutch community of practice. Marine Policy, 126: 104371.

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.

Sumaila, U. R., Khan, A. S., Dyck, A. J., Watson, R., Munro, G., Tydemers, P., and Pauly, D. 2010. A bottom-up re-estimation of global fisheries subsidies. Journal of Bioeconomics, 3: 201–2225.

Suuronen, P., and Gilman, E. 2020. Monitoring and managing fisheries discards: new technologies and approaches. Marine Policy, 116: 103554.

Suuronen, P., and Sardà, F. 2007. The role of technical measures in European fisheries management and how to make them work better. ICES Journal of Marine Science, 64: 751–756.

Task Force Duurzame Noordzeevisserij. 2006. Vissen met tegenwind: Advies Task Force Duurzame Noordzeevisserij. In G. Van Balsfoort, T. IJlstra, N. A. Steins, and F. Vroegop (eds.). Drukkerij Romer. Schiedam.

Uhlmann, S. S., Ulrich, C., and Kennelly, S. J. 2019. The European landing obligation: Reducing discards in complex, multi-species and multi-jurisdictional fisheries. Springer Open. https://doi.org/https://doi.org/10.1007/978-3-030-03308-8.

Van Helmond, A. T. M., Mortensen, L. O., Plet-Hansen, K. S., Ulrich, C., Needle, C. L., Oesterwind, D., Kindt-Larsen, L. *et al.* 2020. Electronic monitoring in fisheries: lessons from global experiences and future opportunities. Fish and Fisheries, 21: November 2019, 162–189. https://doi.org/10.1111/faf.12425.

van Hoof, L., Steins, N. A., Smith, S., and Kraan, M. 2020. Change as a permanent condition: a history of transition processes in Dutch North Sea fisheries. Marine Policy, 122: 104245.

Van Riel, M. C., Bush, S. R., van Zwieten, P. A. M., and Mol, A. P. J. 2015. Understanding fisheries credit systems: potentials and pitfalls of managing catch efficiency. Fish and Fisheries, 16: 453–470.

Veiga-Malta, T., Feekings, J., Herrmann, B., and Krag, L. A. 2019. Industry-led fishing gear development: can it facilitate the process? Ocean and Coastal Management, 177: 148–155.

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.

Villasante, S., Antelo, M., Christou, M., Fauconnet, L., Frangoudes, K., Maynou, F., Morato, T. *et al.* 2018. The implementation of the landing obligation in small-scale fisheries of southern European Union countries. In The European Landing Obligation: Reducing Discards in Complex, Multi-Species and Multi-Jurisdictional Fisheries. https://doi.org/10.1007/978-3-030-03308-8_5.

VisNed. 2020. Samenvatting aanlandplicht 2020. Nieuwsbrief (8 januari 2020). https://www.visned.nl/aanlandplicht/aanlandplicht-GVB-2020-samenvatting

Walsh, S., Engas, A., Ferro, R., Fonteyne, R., and Marlen, B. van. 2002. To catch or conserve more fish: the evolution of fishing technology in fisheries science. In E. D. Anderson (Ed.), ICES Marine Science Symposia(Issue Appendix 1, pp. 493–503). ICES.

Wilson, D. C., Raakjær Nielsen, J., and Degnbol, P. 2003. The fisheries co-management experience: Accomplishments, challenges and prospects. Kluwer Academic Publishers. Dordrecht

Yandle, T., Hajj, N., and Raciborski, R. 2011. The goldilocks solution: exploring the relationship between trust and participation in resource management within the New Zealand commercial rock lobster fishery. Policy Studies Journal, 39: 631–658.

Handling Editor: Michael Pol