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Original Article

Fishing gear transitions: lessons from the Dutch flatfish pulse trawl

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This paper focuses on the transition in the Dutch cutter fleet-targeting flatfish, from the conventional beam trawl to the pulse trawl fishing gear. In doing so, we explore the process of gear transition, presenting the challenges that fishers and policy-makers face. The pulse trawl technique represents a particularly controversial gear transition as it makes use of electricity, which has been banned by the European Union since 1988. However, it is seen by those developing it in the Netherlands as an important alternative fishing gear to the conventional beam trawl technique, which is becoming increasingly inefficient with rising fuel prices and well-documented impact on benthic habitats. By using a multi-level perspective on socio-technical transitions as the analytical framework, we explore the development of the pulse trawl and the interaction between different levels. We also discuss the influence of technology-push on its transition into practice and regulation. This paper demonstrates the importance of social dimensions in the adoption of new fishing gears and in doing so contributes to our knowledge on how technological transitions in fisheries can be managed.

Keywords: multi-level perspective, pulse trawl technique, socio-technical transitions, technology-push, transition theory.

Introduction

Catchability and fishing mortality in commercial fisheries are directly related to the type of gear that is employed by fishers (Hilborn and Walters, 1992). Whether a fishery can reduce its fishing impact is therefore partly dependent on the uptake of new fishing gears (Rijnsdorp *et al*., 2008; Eigaard *et al*., 2014). By adopting new gears, or altering existing fishing gears, fishers are able to positively (and negatively) influence their impact on the sustainability of a fish stock and on the surrounding marine environment. Like other processes of technological change, the shift to more sustainable fishing gear is complex due to high degrees of uncertainty and contestation around innovations (Dewees and Hawkes, 1988; Van Ginkel, 2001; Bavinck and Karunaharan, 2006; Bush and Belton, 2012). New fishing gear may conflict with the (short-term) economic goals and safety concerns of fishers (Eigaard *et al*., 2014). Besides these potential conflicts, new fishing gear also needs support from a wide group of actors, including industry, states, scientists and NGOs, to prevail in both practice and policy. The introduction of new gears therefore goes far beyond technology design and innovation to include what Geels (2004) and colleagues (Geels and Schot, 2007; Grin *et al*., 2010) label socio-technical transitions.

The Dutch demersal fishing fleet is an example of a fishery that has undergone a series of substantial gear transitions in response to technical and market developments and changing fishing regulations. Technological innovation was aimed at improved fishing efficiency. The first major innovation, after earlier introductions of steam and motorized propulsion, took place in the 1960s when the demersal fleet shifted from employing an otter trawl targeting groundfish to a beam trawl-targeting flatfish (Rijnsdorp and Millner, 1996; Rijnsdorp *et al*., 2008). Although beam trawling for flatfish is a very efficient fishing technique in terms of catch per unit effort, it requires a high-energy input (Rijnsdorp *et al*., 2008), causes substantial mortality of both undersized target and non-target fish, leads to changes in the species composition of invertebrates (van Marlen *et al*., 2014), and causes physical disruption of the seabed (Depestele *et al*., 2016). These negative effects triggered research and development into alternative, economically efficient fishing techniques with lower impact. A second technical innovation was the replacement of the beam by what has been called a SumWing. A hydrodynamic wing-shaped "beam"; reducing weight and bottom contact and therefore drag resulting in less oil consumption with 20% (Stichting voor Duurzame Visserijontwikkeling, 2010). The third technical innovation was the replacement of tickler chains used for mechanical stimulation of the seabed with the beam trawl to the use of electrodes giving an electrical stimulus. As outlined by Soetaert *et al.* (2013), this alternative electro-trawl technique, otherwise known as a "pulse trawl", was seen as an alternative for diminishing the ecosystem effects of the conventional beam trawl.

The actual process of innovation and adoption is in many ways contrary to the initial hopes of the Dutch government, scientists and fishers who hoped the pulse trawl gear would quickly integrate into the industry given its apparent benefits. Despite the adoption of the pulse trawl in the Dutch cutter fleet delivering improved economic efficiency and ecological performance, the process of adoption has been highly contested. Low levels of consensus around the use of electricity in fishing, which has been banned in the European Union since 1988 (Quirijns *et al.*, 2013), and the high levels of uncertainty around the physical impact on non-target species and benthic habitat, have contributed to opposition from industry and environmental groups alike. In this paper, we explore how this process of socio-technical innovation became so contested, and how this contestation was played out in the Netherlands and in Europe. In doing so, we offer key insights into the wider assumptions of how "new and improved" fishing gears can be effectively introduced by moving away from technological push (Di Stefano *et al.*, 2012; Peters *et al.*, 2012) and considering the social dimensions of technological transitions.

Using a retrospective case study approach, we reconstruct the introduction and uptake of the pulse trawl since 1988 (for a timeline of events, see Supplementary data, A). Data were collected through semi-structured interviews with a purposive sample (Curtis *et al.*, 2000) of 17 actors and institutions, ranging from scientists, fishers, policy-makers, fisheries representatives, engineers, and NGO's involved in the transition process of the pulse trawl in the Netherlands. Two respondents refused to cooperate with an interview and gave brief written statements explaining their refusal. All interviews were recorded, transcribed, then coded for analysis based on a predetermined framework. Data were triangulated from multiple sources to ensure that evidence was reconstructed accurately, in terms of facts and sequence (De Vaus, 2001).

The following section introduces the multi-level perspective (MLP) of transition theory as the analytical framework for this case study. We then present the socio-technical transition of the pulse trawl technique in four phases that correspond to the major decision-making events from its introduction in the 1970s to the present. The case is followed by a discussion, which summarizes the key lessons learned for better understanding and managing the process of fishing gear innovation and transition. The final section draws conclusions and outlines recommendations for policy and further research.

A transition theory approach to gear innovation

Technological change is commonly framed in terms of the creative tension between technology-push and demand-pull processes (Di Stefano *et al.*, 2012; Peters *et al.*, 2012). Technology-push in particular emerges from the idea that new technologies are instruments to solve environmental and developmental problems, which is also referred to as a technological fix (Paredis, 2011). As Nye (2014) argues, such "technological fixes" presume that failure to change is an intrinsic shortcoming of human capacity and therefore aims to circumvent these shortcomings rather than to address changes in practices and lifestyle. According to Sarewitz and Nelson (2008) only in a few situations technological fixes are successful, depending on the context of the complex socio-technological system. In recognition that technological change occurs as a result of (rather than despite) social and political processes, attention has now turned to a so-called co-evolutionary understanding of *social*-technical change (Schot and Geels, 2008; Grin *et al.*, 2010): paying attention to both technological innovation and the wider social, political, and economic context in which the innovation is embedded.

The consequence of this co-evolutionary understanding is that technological transitions are neither linear nor rational processes. Instead, the innovation and introduction of technologies is understood as dependent on the continual interplay between technical knowledge and developments on the one hand and socio-cultural values, different power structures, and social innovation on the other (Bos, 2004; Paredis, 2011). This co-evolutionary perspective is understood in terms of "socio-technical transitions" (Rip and Kemp, 1998; Rotmans and Loorbach, 2009; Grin *et al.*, 2010). These transitions trace the dynamic interface between the influence of social values over technology development and adoption, as well as how power relations change through technologies and shape everyday practices (Paredis, 2011). As argued by Johnson and Wetmore (2009), "understanding how values are entwined in socio-technical systems is crucial to steering technology to a future we want" (p. 205). Therefore, any analysis of technological adoption should not only focus on the technology itself but also on social processes of design, use, and learning that influence the form and function of technical hardware.

The analysis of socio-technical transitions is structured by the MLP of Geels (2004). The MLP seeks to explain how innovations emerge and are mainstreamed in practice and regulation over time by breaking transition processes into the socio-technical niche, regime, and landscape levels as is shown in Figure 1. Socio-technical transitions begin at the niche level, described as protected spaces that enable emerging innovative technologies to be tested and developed (Hermans *et al.*, 2013). These niches are crucial to transitions, because they provide spaces for learning, experimentation, and innovation in reference to, but often unconstrained by, prevailing institutional and economic norms and practices. Within a niche, actors interact, share and deliberate over their ideas, creating their own norms, discourses, and practices and social networks. But niches do not exist in a vacuum. They develop in reference to what is referred to as the regime level—a set of actors and institutions, which coordinate and steer innovations according to prevailing regulative, normative, and cognitive rules. The regime level coordinates and aims to guide and steer innovation at the niche level along a predictable trajectory (Grin *et al.*, 2010). In doing so, it balances regulation with innovation through the alignment and stability of rules (Geels, 2004). Finally, these niche and regime levels are embedded in the landscape level, which encompass processes beyond the direct influence of regime and niche actors such as demographic trends, political ideologies, societal values, and macro-economic patterns (Geels and Schot, 2007; Geels, 2011).

By understanding the composition and interaction in and between the three MLP levels, it is possible to reconstruct how transitions can be achieved, including those towards complex outcomes such as sustainability (Grin *et al.*, 2010; Hermans *et al.*, 2013). At the centre of the approach are questions around the extent to which innovations, such as new fishing gear, can be mainstreamed in policy and practice. For instance, how do institutions and actors in existing regimes foster innovations? What conditions are necessary for a niche innovation to be taken up and restructure the regime? Can niche innovations replace a regime, or do they

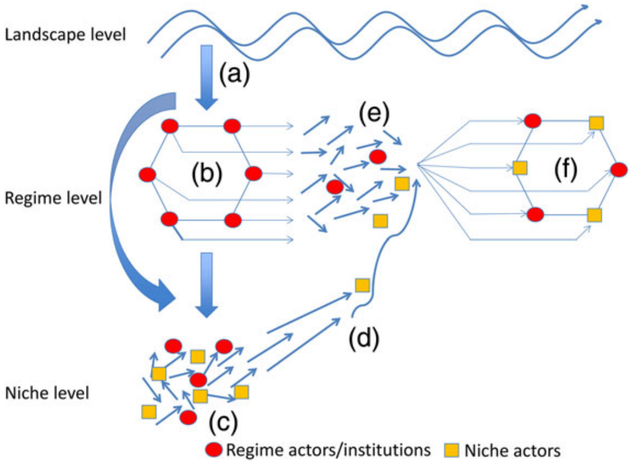

Figure 1. Schematic explanation of the MLP. (a) Landscape-level developments exert pressure and influence regime and niche levels; (b) Regime-level consists of a network of actors and institutions that share a set of regulative, normative, and cognitive rules. (c) Multiple innovations are developed at the niche level by niche actors in combination with regime actors. (d) Innovations emerge that challenge the regime and start a process of realignment between the niche and regime level. (e) Regime is destabilized by the landscape level creating an opportunity for innovations to break through. (f) If the niche innovation successfully aligns with the regime level, then an opportunity for new regime configuration emerges (adapted from Schot & Geels, 2008). This figure is available in black and white in print and in colour at *ICES Journal of Marine Science* online.

instead contribute to changes in the behaviour, routines, and practices of regime actors? It is also possible to determine the extent to which changes in technology are "pushed" by regime and niche actors.

There is a continuous drive for modifying fishing gears and practices around the world, with commercial fishers constantly introducing technology to remain economically competitive, enhance the performance of their equipment, and/or respond to changes in rules and regulations (Valdemarsen, 2001; Tietze *et al.*, 2005). Advances in fishing technology over the last century have been instrumental in increasing the efficiency of fishing fleets contributing to the overexploitation of fish stocks (Agboola, 2014; Eigaard *et al.*, 2014). In response, fishing technologists have started to focus more on conservation-oriented goals of gear development, placing innovations in fishing technology as a key input to sustainably managed fish stocks (Kennelly and Broadhurst, 2002; Eigaard *et al.*, 2014). In the rest of this paper, we seek to understand how fishing technologies can be better understood as socio-technical transitions, and the consequences such an understanding might have for managing gear-related sustainability transitions.

Four phases of gear transition

Phase 1: Experimentation, ban and research

The first trials with marine electro-trawls in Europe were conducted in the 1970s in the Netherlands (De Groot and Boonstra, 1970; Boonstra and De Groot, 1974; Agricola, 1985), Belgium (Vanden Broucke, 1973), Germany (Horn, 1976), and the UK (Horton, 1984). But it was not until 1986 that the first attempts were made to commercialize marine electric fishing gear in the Netherlands (Van Marlen, 1997). A prototype was tested in 1987 aboard the commercial vessel GO-65 and it showed higher sole catches and lower plaice catches compared to the conventional beam trawl. No improvement in size selectivity was found, but further research was advocated (Van Marlen, 1997).

In 1988, however, all research and development was halted when the European Union put a ban on electrical fishing in place. According to Linnane *et al.* (2000) and Van Marlen (1997), the ban reflected the fear that electro-trawls would lead to a rapid and uncontrolled increase in fishing efficiency. At the time, the beam trawl fleet was already under severe international criticism, with poor regulation and control resulting in overshooting quotas (Soetaert *et al.*, 2013). As one respondent from the Dutch fishing industry argued, the introduction of an even more efficient fishing technique at that time was therefore politically untenable. As a result of the ban, all research and development on electrical fishing techniques was halted throughout Europe. And with a stabilized crude oil price, the dominant motivation to develop an alternative, more efficient fishing gear to replace the conventional beam trawl became less urgent.

However, the results and knowledge that had been built up before the ban in 1988 clearly demonstrated the potential for an electric fishing gear on minimizing impacts on benthic habitats and species. Recognizing this, the Dutch company Verburg-Holland B.V. decided to resume research and development of an electric fishing gear in 1992 (Soetaert *et al.*, 2013), with direct support from the Dutch Ministry in the form of time on one of their research vessels. The government was willing to invest in research on an electric fishing gear despite the ban. A former employee of the Ministry clarified why research commenced when the gear had been banned. He argued that, "There was quite some criticism on the [traditional] beam trawl, so then it is wise to look for an alternative. I think that the pulse trawl technique was considered to be the main alternative, because the Ministry had already invested a lot in it".

By 1998, both Verburg-Holland B.V and the Ministry were optimistic about the progress on the pulse trawl technique and they approached the Dutch Institute for Fisheries Research (RIVO, currently *IMARES*) to give scientific guidance to the further development of a pulse trawl gear. The fishing industry also became involved through the Federation of Fishing Associations (FFA, currently *VisNed*), which represented a significant part of the demersal fishing industry (Van Marlen *et al.*, 2014). Their involvement led to the development of a pulse trawl with a width of 12 m to match the common size of the conventional trawl and open up the possibility of retrofitting existing vessels (Van den Berge and De Bruijn, 2000a).

Despite investments in the pulse trawl project by the fishing sector during the 1990s, many fishers did not feel the need to invest in an alternative fishing technique for the beam trawl. They were sceptical about the pulse trawl and disagreed with the societal critique on the conventional beam trawl (Van den Berge and De Bruijn, 2000a). However, according to the chair of the FFA at the time, the wider fishing industry did see the need to solve problems associated with bycatch and the high fuel consumption (Van den Berge and De Bruijn, 2000b). To enable continued research on the pulse trawl, an experimental license for research was sought by the Ministry at the EU. Although the licence was granted, the Ministry only agreed to start discussing options to legalize the use of electricity if research results would be gathered aboard a commercial vessel during a pilot project. Initiatives to undertake such a project were initially stranded around disagreement about who should pay for the gear and for hiring a commercial vessel (Van den Berge and De Bruijn, 2000b). It took until 2004 before this could take place.

Phase 2: research aboard a commercial vessel

In 2004, the pulse trawl system was ready to be tested aboard a commercial vessel. For this, the flatfish cutter UK153 was selected by the Agricultural Economics Research Institute (LEI) in consultation with representatives of the fishing industry. One year later, the Ministry initiated a steering group for the pulse fishing pilot, consisting of the Ministry and representatives from the two industry associations, the FFA and the Dutch Fishers's Federation (*Nederlandse Vissersbond*). Scientific advice was provided by the Institute for Marine Resources and Ecosystem Studies (IMARES) and LEI, both of which fed back research results during the steering group's meetings.

Meanwhile, wider pressure on the sector to innovate was building. The Dutch cutter fleet was faced with further economic pressure due to rising fuel prices and decreasing fish quota (Ministry of Agriculture, Nature and Food Quality, 2006). At the same time, the European Commission announced support for the development of sustainable fishing techniques by increasing the budget available for sustainability linked innovations (European Commission, 2004). In response, a group of interested beam trawl fishers, Verburg-Holland B.V. and the steering group met in 2006 to discuss the wider introduction of the pulse trawl (Visserijnieuws, 2006).

A major boost to the ambitions of the Dutch industry was given in 2005 when the European Commission indicated that it would be possible to further expand the introduction of the pulse trawl if the International Council for the Exploration of the Sea (ICES) would provide a "positive advice" (Visserijnieuws, 2006). The advice that ICES forwarded to the Commission's Scientific, Technical and Economic Committee for Fisheries (STECF) was cautiously positive: despite clear benefits to benthic species and habitats and clear gains in fuel efficiency, concern was raised about potential spinal damage to cod, potential effects on invertebrates and effects on electric sensory systems of elasmobranchs (ICES, 2007). As outlined in the STECF's written conclusion, "Although the development of this technology should not be halted, there are a number of issues that need to be resolved before any derogation can be granted" (p. 6). However, the EU ultimately rejected this assessment and introduced a derogation (under Annex III (4) of Council Regulation (EC) No. 41/2006) for 5% of the beam trawler fleet by Member States fishing in ICES zones IVc and IVb to use the pulse trawl on a restricted basis, provided that attempts were made to address the concerns expressed by ICES.

Although permission was granted from the European Commission for a wider introduction of the pulse trawl technique, the Dutch fishing sector remained pessimistic about the technique due to technological problems with the gear and lower landings compared with conventional beam trawls. As one interviewed researcher outlined, the fishing sector representatives withdrew their support to the pilot project during a meeting of the steering group at the end of 2006. Decreasing plaice quota and the decreasing total landings of the Dutch cutter fleet negatively affected the revenues, while costs kept rising due to the rising fuel prices, leading to a negative net economic result. As a result of this, the majority of the Dutch fishing sector did not feel the need to keep investing in an innovation they did not believe in.

Phase 3: The breakthrough in the Dutch cutter sector

Meanwhile, the Ministry had initiated the "Task Force for Sustainable North Sea Fisheries" (*Task Force Duurzame Noordzeevisserij*) in 2005 because of the deteriorating economic situation in the North Sea fisheries. This Task Force consisted of representatives of the fishing industry, Civil Society Organisations (CSO), scientists, and policy officers. The Task Force was instructed to develop an economic and environmental sustainable perspective for the North Sea cutter fleet (Task Force Sustainable North Sea Fisheries, 2006). In their final report, "Fishing with Headwind" (2006), they described the urgent situation in the Dutch fishing industry and advised to establish a Fisheries Innovation Platform (*Visserij Innovatie Platform*, FIP) to steer innovations in the fisheries sector. One of the outcomes was the establishment of Study Groups (*kenniskringen*) consisting of fishers from the same fleet, but from different regions in the Netherlands to stimulate and empower fishers to innovate towards more sustainable fisheries (see De Vos and Mol, 2010).

The FIP saw the pulse trawl technique as a priority for reducing fuel consumption and discards in sole fisheries. As a consequence, the Study Group "Pulse & SumWing" was established in 2008, consisting of fishers that were willing to test and develop the pulse trawl technique in addition to the SumWing. As two interviewees described, the fishers involved in this study group had closely followed the pilot project of the UK153 and, in contrast to the majority of the fishing industry, saw potential in this fishing technique to catch an equivalent amount of sole with considerably lower fuel costs compared with the conventional beam trawl.

The Ministry managed to arrange an investment scheme with the European Commission in 2008 for five vessels owned by fishers participating in the Study Group. This scheme covered 40% of the investment in a pulse system, with a maximum investment of €176,000 per vessel (Visserijnieuws, 2008). The goal was to gain broad experience with the pulse trawl and to share these experiences with other entrepreneurs involved in beam trawl fishing. By doing so, the Ministry wanted to stimulate the further introduction and the future use of the pulse trawl gear (Visserijnieuws, 2008). In 2009, both the SumWing pulse and pulse trawl were installed on the vessels and within months these proved to be both reliable and profitable. Other interested skippers however struggled to get loans from the bank to invest in the pulse trawl technique due to the ongoing uncertainty over whether the 5% derogation for the experimental licenses from the European Commission would be extended. According to a researcher from the LEI, and corroborated by a former employee of the Ministry, this all suddenly changed: "After a leading fishing company had ordered four Pulse Wings, the other fishers started to ask me where and how they could register. There were only a few more days to go before the registration period ended". This order convinced other fishers that the pulse trawl technique was reliable and profitable. Eventually the number of registered fishers exceeded the number of available pulse trawl licenses, so now the amount of licenses became a stagnating factor to a wider transition to the pulse trawl technique (Visserijnieuws a, 2010).

Urged by the fishers, both the Dutch Fishers's Federation and VisNed sought more experimental licenses from the Dutch Ministry with support from both WWF and the North Sea Foundation (Visserijnieuws b, 2010). During the Agriculture & Fisheries Council (AGRIFISH) of December 2010, it was decided that the number of experimental licenses could be expanded to 42 based on Article 43,850/1998, which is a regulation for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms (Council of the European Union, 1998; Rijksoverheid, 2010). However, these 42 experimental licenses were not enough to enable all registered fishers to make the transition towards the pulse trawl technique.

Phase 4: European resistance and break through

After this expansion, concern around the pulse trawl gear outside the Netherlands grew. In response to the concerns and criticism of European fishers, meetings were organized by the steering group pulse fishing to provide more information to fishers in Belgium, Germany, and the UK (Visserijnieuws, 2012). When asked how these meetings were, a former employee of the Ministry said:

> We spoke to one of those fishermen that had stood in the article of the Sunday Times. I asked him: Do you really believe that these four cutters, which are the culprits according to you, come here every week all the way from Texel to catch dead sole? Do you truly believe that they come here to fish for dead sole? Why would only you catch dead fish, while they catch living ones? I did not hear the man anymore during the rest of the meeting.

This quote illustrates a degree of pushback between the Netherlands and other EU countries. Where we see a clear technology-push by the Netherlands, we also see a clear pushback reaction from other European member states because of the remaining uncertainty around this new fishing gear and notions of protectionism (Kraan *et al.*, 2015). The underlying mechanism appears the more a technology is "pushed", the more resistance it generates.

Despite the opposition from other North Sea fishing nations, the Dutch government began to incorporate the pulse trawl technique into several longer term management plans, for example the VIBEG-agreement (Rijksoverheid, 2012). This agreement prohibits bottom trawling in 25% of the Dutch North Sea Coastal Zone from 2016 onwards, including two Natura 2000 areas: the North Sea Coastal Zone and the Vlakte van de Raan delta next to the Belgium border, and is signed by a coalition of environmental NGOs, industry and government. The consequence is that fishers will only be able to continue fishing in these "prohibited" areas with gears that do not affect benthic habitat, giving further impetus to the use of the pulse trawl.

But despite the support for these plans, their implementation remains dependent on the decision of the European Commission to allow a wider introduction of the pulse trawl technique by expanding the number of licenses or by the permanent admission of the pulse trawl technique (Visserijnieuws, 2011). Meanwhile, ICES urged that a control and enforcement system needed to be setup before the permanent admission or wider introduction of the pulse trawl technique (ICES, 2012). One respondent from the Ministry stated that the permanent admission for the pulse trawl technique was met with too much resistance from other EU member states. Furthermore, efforts to expand the derogation from 5% to a proposed 40% also encountered resistance from other EU member states and the EC.

In 2014, an alternative strategy was adopted by the Netherlands, to expand the number of licenses. At the time, the European Council was discussing a subsidy scheme for the modernization of the European Fisheries Fund (EMFF). A provision was taken up, following a Dutch proposition, in the regulation of the EMFF to alter the technical measures (The EMFF is the financial instrument that helps deliver the reforms of the Common Fisheries Policy (CFP) and that will support the implementation of the EU Integrated Maritime Policy (European Commission, 2014).). However, as the EMFF has no relation to the technical measures this unusual procedure was met with little sympathy in Brussels. According to one respondent of the Ministry, no one in Brussels seemed to understand why the Netherlands was doing this. But for the Netherlands it was a very important political issue. As a former Ministry employee observed: "The fishing industry really wanted more licenses, expectations had been raised and there were hardly any scientific objections against this fishing technique. With some power play we got it in the regulation". The other European member states were unable to vote against the Dutch provision in the regulation, because then they would also vote against a regulation that contained important subsidies to them.

Still the EP also had to vote on the provision in the regulation. The parliament's rapporteur decided not to include the expansion in the EMFF, as it had no place in these negotiations. The State Secretary for the Ministry of Economic Affairs then decided to schedule a meeting with the European Commissioner of Maritime Affairs and Fisheries and the president of the European Fisheries Council (Rijksoverheid, 2014). During that meeting it was agreed that the expansion to 10% of the Dutch cutter fleet could be granted, based on Article 14 (This article states that: To facilitate the introduction of the obligation to land all catches in the respective fishery in accordance with Article 15 ("the landing obligation"), Member States may conduct pilot projects, based on the best available scientific advice and taking into account the opinions of the relevant Advisory Councils, with the aim of fully exploring all practicable methods for the avoidance, minimization and elimination of unwanted catches in a fishery (Rijnsdorp et al., 2014). This meant that now approximately 84 licenses were made available for using the pulse trawl technique (Rijksoverheid, 2014; Turenhout *et al.*, 2014). According to a former employee of the Ministry, the expansion was perceived as a procedural scandal by some European member states.

Currently, the pulse trawl technique is a contentious fishing technique that has been broadly implemented in the Netherlands. However, there is clear pushback from other European member states being directed to expressing concern about the remaining uncertainty around this new fishing gear (Kraan *et al.*, 2015). In other words, it is only at a later stage in the transition process that Dutch actors and institutions began to see that their technology-push driving the "license push" backfired the process of obtaining permanent admission/expansion of the pulse trawl technique within the EU. It even resulted in a growing resistance to the pulse trawl in other European member states (Visserijnieuws, 2015). Dutch actors and institutions are now striving for an increase of the acceptance of the pulse trawl technique among a wide group of stakeholders and other EU member states through increased involvement of international stakeholders, the setup of a research agenda and increased transparency through the website www.pulsefishing.eu. It was agreed to give an annual progress report to the NSAC, so that everyone can follow and comment on the progress around the pulse trawl technique (Visserijnieuws, 2015). Thereby the function of the NSAC Pulse Focus Group more or less resembles the function of the Study Groups, but now at the European level. A summary of the major events during the pulse trawl transition can be found in Table 1.

Discussion

The introduction of the pulse trawl basicly represents a socio-technical transition that led to wide ranging changes at the regime level of the beam trawl fishery in the North Sea. As the Netherlands own 75% of the North Sea sole (*Solea solea*) quota (Productschap Vis, 2012), a substantial part of all sole landings in Europe can be attributed to vessels using a pulse trawl. Overall, this case study shows that understanding the pulse trawl in socio-technical terms allows us to

Table 1. Summary of major events during pulse trawl transition organized by phase and transition level.

Socio-technical fishing gear transition			
Phase 1	**Phase 2**	**Phase 3**	**Phase 4**
Transition levels			
Landscape			
Stable oil prices, but growing concerns and criticism on effects conventional beam trawl	Growing concerns and criticism on conventional beam trawl. Fish quota are under pressure and oil prices rise	High oil prices, poor economic results and concerns and criticism on conventional beam trawl result in high pressure	Concerns and criticism on the effects of trawling continue to grow and oil prices decrease
Regime			
Dutch regime actors and institutions stimulate research and development on a pulse trawl at the niche level	Cooperation between regime and *selected* niche actors leads to technology push	Dutch regime actors organize themselves in the FIP and Study Group to facilitate the breakthrough of the pulse trawl	European regime actors and institutions are increasingly being involved (North Sea AC) by Dutch regime actors and institutions
Niche			
Weak cooperation between niche actors; weak pressure from landscape level	The pulse trawl is stabilizing into a dominant design	Pulse trawl proofs to be reliable and profitable and the gear is ready to breakthrough	Research continues on the effects of the pulse trawl

identify how new gears change fishing behaviour, routines and practices (in line with wider observations of Geels and Schot, 2007; Grin *et al.*, 2010). Changes in fishing behaviour, routines and practices are not limited to fishers, but also include inspection authorities, fishery managers, government officials, people working in maintenance and distribution networks as well as research (Van Slooten, 2007). One could even argue that the observed transition has also led to changes in cultural and symbolic meanings of what constitutes fishing (see Bear, 2012). Fishing with electricity is nowadays part of the Dutch fishing culture. However, other fisheries actors might still perceive this technique with fear or have basic objections against the use of electricity to catch fish.

The socio-technical transition of the pulse trawl fishery demonstrates the basic importance of recognizing the social and political changes that are required to create fishing gear configurations that work in practice but also in policy (Rip and Kemp, 1998). How the Dutch cutter fleet eventually took up the pulse trawl technique can be explained in terms of a co-evolutionary socio-technical transition (as defined by Schot and Geels, 2008); meaning that the technological development is strongly linked to developments in the social domain. So while it appears that the uptake of the pulse trawl from a socio-technical niche to the regime level was successful, it remains partial in two key aspects. At the national level restrictions remain on the number of vessels licenced by the EU, and adoption at the European level (and therefore in other member states) is also limited. These dual outcomes of the innovation process of the pulse trawl technique can be explained by applying an MLP.

Consistent with the MLP, landscape level dynamics out of the control of the regime and niche actors, initially stimulated action—notably through the Task Force Sustainable North Sea Fisheries (2006). Rising oil prices and the criticism and concerns on the environmental impact of the conventional beam trawl exerted pressure on the regime level to come up with an alternative fishing technique. With the setup of the FIP, we saw how representatives of the fishing industry, NGOs, scientists, and policy officers organized themselves to respond and incorporate these landscape pressures into both the niche and regime level. As noted in other sectors (Grin *et al.*, 2010; Paredis, 2011; Hermans *et al.*, 2013), technology actors (firms, governments) tend to exclude certain actors and solely focus on technological development, while social aspects are being neglected. We see this in the pulse trawl case as well, where actors organized themselves around the development of the technology within the Netherlands, without adequately focusing on the highly contested nature of the technology at the European level. The case demonstrates the pitfalls of transition strategies that have “pushed” through technologies while little attention was paid to changes required in the regime in which its application is embedded.

But what we also see is that Dutch actors and institutions mainly adopted the technology-push strategy beyond the national borders of the Netherlands. Before that point, within the relative confines of the Dutch fishing sector arena, the transition process was managed through a novel set of legitimising arrangements that did take careful consideration of the social dimensions of the gear transition.

The first of these arrangements, observed in Phase 1, was the funding and close interaction between the Dutch Ministry as the dominant regime actor in the Netherlands, and the key niche actors, such as the company Verburg and the RIVO, who were responsible for researching and developing the pulse trawl technique after the ban on electric fishing. Second, in Phase 2, was the bridging role that the steering group pulse fishing played in bringing together the niche and regime actors. The role of the steering group was basic in promoting the pulse trawl technique and in trying to persuade Dutch fishers to make a transition. It was instrumental in facilitating the movement of the pulse trawl gear into Dutch policy and regulation. Third, after renewed support of the pulse trawl gear in Phase 3, the Study Group Pulse & SumWing provided a protected learning environment around the niche. Allowing for participating fishers to advocate that the pulse trawl technique was both reliable and profitable beyond the niche to the Dutch cutter sector.

These organizational innovations demonstrate that active engagement with a wide range of social actors and institutions can produce outcomes that are more legitimate and which account for a wider array of political and economic factors in technological change (Miller *et al.*, 2013). These organizational innovations demonstrate the central function of social dimensions of transitions (cf. Di Stefano *et al.*, 2012; Peters *et al.*, 2012). By the application of the MLP, it became clear that the emerging of the organizational innovations reflects a degree of learning throughout the transition. While little attention was paid to the social processes in the first two phases, the setup of legitimizing and facilitating arrangements, like the FIP and the Study Group, illustrate how the inclusion of social, financial, and political dimensions resulted in the successful uptake of the pulse trawl technique by the Dutch flatfish cutter fleet in the third phase (cf. Lawhon, 2012). Intriguingly, despite the successful breakthrough and acceptance of the pulse trawl technique in the Dutch cutter fleet, the Dutch actors and institutions fell back into a technology-push strategy when addressing the European regime in the fourth phase.

We argue that the failure of the Dutch regime actors to adequately consider the social and political dimensions of the pulse trawl at the European level can be characterized as a technology push, which resulted in a "license push". This might be explained by poor recognition by the Dutch actors and institutions of the fragmented nature of environmental policy at the European level of the regime, which does not solely consist of the Netherlands but also incorporates the EU in the form of the European Parliament, Commission, and other EU member states (see, e.g. Jordan *et al.*, 2012). As innovators are not always aware of the presence of other stakeholders, or the effect that fishing gear innovations have on these other stakeholders, the transition process can be derailed. Incorporating a broader set of stakeholders however does not automatically solve this problem of fragmentation. Without considering the organizational set-up of this inclusion of stakeholders, the risk is that other actors can submit an endless wish list of research topics to slow down or halt the breakthrough of an innovation. Recognizing this, might lead to another set of organizational innovations, this time at the EU level.

A considerable amount of research has been conducted on the potential ecosystem effects of the pulse trawl compared to other implemented fishing gears within the EU. However, this case clearly demonstrates the importance of credibility, saliency and legitimacy in the uptake of science to policy (Cash *et al.*, 2002). Gear transitions are influenced not only by the best available science, but also by how fair, credible and relevant the arguments are to citizens and stakeholders. As Wilson (2009) notes, although the desire for scientific answers is great, automatic authority of science belongs to the past. As a result, the inclusion of stakeholder perspectives in science and management in meaningful ways is becoming increasingly important (Röckmann *et al.* 2015). It is exactly this pattern we observe for the pulse trawl transition.

Replacing the conventional beam trawl with the pulse trawl implies changes in the sociotechnical configuration that goes beyond the Dutch border. In doing so, the case clearly shows the importance of including the social and political context in which technological innovations are embedded. In line with wider observations, the case lends further weight to the need to see the governance of socio-technical transitions as a "irreducibly politicized process" that has to be seen in the wider context of how "societal goals are determined and revised, collective decisions are enforced, and resources are authoritatively allocated" (Meadowcroft, 2009, p. 335). By breaking down this process into recognizable phases, and in doing so, reconstruct how a technology was "pushed", by who and in whose interest, we can better understand patterns and practices for increasing the likelihood of successful transition management. In other words, we can understand how technological push (including our "licence push") can be avoided. We are convinced that in doing so, the actors and institutions in the pulse trawl case may have been able to steer a far smoother and more manageable path for a *potentially* more sustainable fishing gear.

Conclusion

Insights into the relationship between technology and society, by understanding the socio-technical systems and the interactions within these systems, gives policy-makers and managers the opportunity to influence future fishery related sustainability transitions. To avoid the pitfalls of technology-push, policy-makers and managers should realize that "even" the design and implementation of fishing gear technology is as much an outcome of social relations between a wide group of actors as it is made up of material electrodes, beams, and nets. In practical terms this means that the success of a gear transition depends on the extent to which a broader group of actors and institutions are involved in the learning and development process within innovation niches.

We also conclude that defining the boundaries of the socio-technological regime at the national level can limit the success of a transition process in multi-level governance arrangements such as the EU. By incorporating European actors and institutions within the regime, just as national level actors from the Netherlands were included, would have reduced the influence of politicized responses at such a late stage. Our results also point to an opportunity for policy-makers at the EU level to be more proactive in supporting sustainability transitions developed within member states. One way this could be done is by installing a framework for technological innovation that can provide guidance for inspection authorities, as well as stakeholder involvement, legitimation processes for licenses, and setting out a strategy for research. Links could also be made to the ongoing regionalization of EU fisheries policy, thereby contributing to a better engagement with the socio-technical context in which the innovative gear will be embedded. Ultimately, such a gear innovation framework would provide a systematic approach for either to reject or accept a fishing gear innovation within the EU. We argue that such a framework would contribute to a climate of innovation and prevent unnecessary delays and complications, while at the same time could build more legitimate checks and balances for innovative gear development.

Based on these results, it is clear that the social configuration in which the fishing technique is embedded plays a major role in how a technique is perceived and used. Although the integration of temporal and structural technological development in fisheries management cannot be considered a trivial task, a socio-technical perspective helps to better understand the process of technological development in fisheries. Uptake of this approach in steering processes at the national and EU level, but also in the advice given by organizations such as ICES, could better deal with the complex and contested nature of technological development in fisheries management.

Supplementary data

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

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References

Agboola, J. I. 2014. Technological Innovation and Developmental Strategies for Sustainable Management of Aquatic Resources in Developing Countries. Environmental Management, 54: 1237–1248.

Agricola, J. B. 1985. Experiments on electrical stimulation of flatfish in beamtrawling during 1984. ICES CM 1985/B, 36.

Bavinck, M., and Karunaharan, K. 2006. A history of nets and bans: restrictions on technical innovation along the Coromandel Coast of India. Maritime Studies, 5: 45–59.

Bear, C. 2012. Assembling the sea: materiality, movement and regulatory practices in the Cardigan Bay scallop fishery. Cultural Geographies, doi: 10.1177/1474474012463665.

Boonstra, G. P., and de Groot, S. J. 1974. The development of an electrified shrimp trawl in the Netherlands. Journal du Conseil/Conseil Permanent International Pour l'Exploration de la Mer, 35: 165–170.

Bos, B. 2004. A matter of control. On the role of plants, animals and humans in technological systems. De Vliegende Beer (In Dutch), Amsterdam.

Bush, S. R., and Belton, B. 2012. Out of the factory and into the fish pond: Can certification transform Vietnamese Pangasius. In Food Practices in Transition: Changing Food Consumption, Retail and Production in the Age of Reflexive Modernity. Ed. by G. Spaargaren, P. Oosterveer, and A. Loeber, pp. 257–290. Routledge, London.

Cash, D. W., Clark, W. C., Alcock, F., Dickson, N., Eckley, N., and Jäger, J. 2002. Salience, credibility, legitimacy and boundaries: linking research, assessment and decision making. KSG Working Papers Series RWP02-046.

Council of the European Union. 1998. Council Regulation (EC) No 850/98 of 30 March 1998 for the conservation of fishery resources through technical measures for the protection of juveniles of marine organisms. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:1998:125:0001:0036:EN:PDF (last accessed 30 October 2014).

Curtis, S., Gesler, W., Smith, G., and Washburn, S. 2000. Approaches to sampling and case selection in qualitative research: examples in the geography of health. Social Science and Medicine, 50: 1001–1014.

De Groot, S. J., and Boonstra, G. P. 1970. Preliminary notes on the development of an electrical tickler chain for sole (*Solea solea* L.). ICES C.M. 1970/B, 4.

De Vaus, M. 2001. Research Design in Social Research. SAGE, London. pp. 219–266.

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.

Depestele, J., Ivanovic, A., Degrendele, K., Esmaeili, M., Polet, H., Roche, M., Summerbell, K., *et al.* 2016. Measuring and assessing the physical impact of beam trawling. ICES Journal of Marine Science, 73 (suppl 1): i15–i26.

Dewees, C., and Hawkes, G. 1988. Technical innovation in the Pacific Coast trawl fishery: the effects of fishermen's characteristics and perceptions on adoption behavior. Human Organization, 47: 224–234.

Di Stefano, G., Gambardella, A., and Verona, G. 2012. Technology push and demand pull perspectives in innovation studies: Current findings and future research directions. Research Policy, 41: 1283–1295.

Eigaard, O. R., Marchal, P., Gislason, H., and Rijnsdorp, A. D. 2014. Technological Development in Fisheries Management. Reviews in Fisheries Science & Aquaculture, 22: 156–174.

European Commission. 2004. Communication from the Commission to the Council and the European Parliament "Promoting Environmentally-friendly fishing methods: the role of technical conservation measures". Nr. Commission Document COM (2004) 438. (In Dutch).

European Commission. 2014. The European fisheries fund (EFF)(2007–2013). http://europa.eu/rapid/press-release_MEMO-14-311_en.htm (last accessed 21 July 2015).

Geels, F. W. 2004. From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. Research Policy, 33: 897–920.

Geels, F. W. 2011. The multi-level perspective on sustainability transitions: responses to seven criticisms. Environmental Innovation and Societal Transitions, 1: 24–40.

Geels, F. W., and Schot, J. 2007. Typology of sociotechnical transition pathways. Research Policy, 36: 399–417.

Grin, J., Rotmans, J., and Schot, J. 2010. Transitions to Sustainable Development; New Directions in the Study of Long Term Transformative Change. Routledge, New York/London. pp. 80–89.

Hermans, F., van Apeldoorn, D., Stuiver, M., and Kok, K. 2013. Niches and networks: Explaining network evolution through niche formation processes. Research Policy, 42: 613–623.

Hilborn, R., and Walters, C. J. 1992. Quantitative Fisheries Stock Assessment: Choice, Dynamics and Uncertainty. Chapman and Hall, New York.

Horn, W. 1976. Rationalization of sole fisheries by means of electrified beam trawls. In: Coun. Meet. ICES/B: 7, Report of the Working Group on Research on Engineering Aspects of Fishing Gear, Vessels and Equipment.

Horton, R. S. 1984. Trials of the electric beam trawling system on MFV Zuiderkruis, summer 1983. Seafish Report IR 1180.

ICES. 2007. Report of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), 23–27 April 2007, Dublin, Ireland. ICES CM 2007/FTC:06, 5–6.

ICES. 2012. Request from France to review the work of SGELECTRA and to provide an updated advice on electric pulse fishing. Special request, November 2012. Book 1.5.6.1., 13–14.

Johnson, D., and Wetmore, J. 2009. Technology and Society. Building Our Sociotechnical Future. MIT Press, Cambridge, MA. 95–205 pp.

Jordan, A., van Asselt, H., Berkhout, F., Huitema, D., and Rayner, T. 2012. Understanding the paradoxes of multilevel governing: climate change policy in the European Union. Global Environmental Politics, 12: 43–66.

Kennelly, S. J., and Broadhurst, M. K. 2002. By-catch Begone: changes in the philosophy of fishing technology. Fish and Fisheries, 3: 340–355.

Kraan, M., Trapman, B. K., and Rasenberg, M. M. M. 2015. Perceptions of European stakeholders of pulse fishing. IMARES report, C098/15: 6–31.

Lawhon, M. 2012. Contesting power, trust and legitimacy in the South African e-waste transition. Policy Sciences, 45: 69–86.

Linnane, A., Ball, B., Munday, B., van Marlen, B., Bergman, M., and Fonteyne, R. 2000. A review of potential techniques to reduce the environmental impact of demersal trawls. Irish Fisheries Investigation, 7: 7–39.

Meadowcroft, J. 2009. What about the politics? Sustainable development, transition management, and long term energy transitions. Policy Sciences, 42: 323–340.

Miller, C. A., Iles, A., and Jones, C. F. 2013. The social dimensions of energy transitions. Science as Culture, 22: 135–148.

Ministry of Agriculture, Nature and Food Quality. 2006. Agriculture Sustainability Report 2005; opting for sustainability. Den Haag, May 2006: 20–22. (In Dutch).

Nye, D. E. 2014. The United States and Alternative Energies since 1980: Technological Fix or Regime Change. Theory, Culture & Society, 31: 103–125.

Paredis, E. 2011. Sustainability transitions and the nature of technology. Foundations of Science, 16: 195–225.

Peters, M., Schneider, M., Griesshaber, T., and Hoffmann, V. H. 2012. The impact of technology-push and demand-pull policies on technical change—does the locus of policies matter? Research Policy, 41: 1296–1308.

Productschap Vis. 2012. Factsheet: North Sea Sole. http://www.pvis.nl/fileadmin/user_upload/pvis/Documenten/Verantwoorde_vis/Visfeiten_Noordzeetong.pdf (last accessed 3 August 2015) (in Dutch).

Quirijns, F., Strietman, W. J., van Marlen, B., and Rasenberg, M. 2013. Flatfish pulse fishing; Research results and knowledge gaps. IMARES Report C193/13: 4–21.

Rijksoverheid. 2010. EU fishing quotas: more herring and plaice, less cod and blue whiting. http://www.rijksoverheid.nl/nieuws/2010/12/15/eu-visquota-meer-haring-en-schol-minder-kabeljauw-en-blauwe-wijting.html (last accessed 21 July 2015) (In Dutch).

Rijksoverheid. 2012. Fishing in natural areas to be limited. http://www.government.nl/news/2012/10/08/fishing-in-natural-areas-to-be-limited.html (last accessed 21 July 2015).

Rijksoverheid. 2014. Agreement to double pulse trawl licenses. http://www.government.nl/news/2014/02/18/agreement-to-double-pulse-trawl-licences.html (last accessed 21 July 2015).

Rijnsdorp, A. D., and Millner, R. S. 1996. Trends in population dynamics and exploitation of North Sea plaice (*Pleuronectes platessa* L.) since the late 1800s. ICES Journal of Marine Science, 53: 1170–1184.

Rijnsdorp, A. D., Poos, J., Quirijns, F. J., HilleRisLambers, R., De Wilde, J. W., and Den Heijer, W. M. 2008. The arms race between fishers. Journal of Sea Research, 60: 126–138.

Rijnsdorp, A. D., Rasenberg, M. M. M., and Wilms, I. 2014. Proposal for pulse trawl research. http://www.nsrac.org/wp-content/uploads/2014/10/20141107-Proposed-research-agenda-pulsefishing_17112014.pdf (last accessed 8 September 2015).

Rip, A., and Kemp, R. 1998. Technological change. *In* Human Choice and Climate Change, Ed. by S. Rayner, and E. L. Malone, 2, pp. 327–399. Battelle Press, Columbus, OH.

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

Rotmans, J., and Loorbach, D. 2009. Complexity and transition management. Journal of Industrial Ecology, 13: 184–196.

Sarewitz, D., and Nelson, R. 2008. Three rules for technological fixes. Nature, 456: 871–872.

Schot, J., and Geels, F. W. 2008. Strategic niche management and sustainable innovation journeys: theory, findings, research agenda, and policy. Technology Analysis & Strategic Management, 20: 537–554.

Soetaert, M., Decostere, A., Polet, H., Verschueren, B., and Chiers, K. 2013. Electrotrawling: a promosing alternative fishing technique warranting further exploration. Fish and Fisheries, 16: 104–124.

Stichting voor Duurzame Visserijontwikkeling. 2010. Fishing with vision: project SumWing. http://www.sdvo.be/websites/1/uploads/files/documents/project-sumwing-definitief_28-1-2014_12_03_23.pdf (last accessed 14 July 2015) (in Dutch).

Task Force Sustainable North Sea Fisheries. 2006. Fishing with headwind: Advice Task Force Sustainable North Sea Fisheries. Task Force Sustainable North Sea Fisheries, 5–47 (in Dutch).

Tietze, U., Thiele, W., Lasch, R., Thomsen, B., and Rihan, D. 2005. Economic performance and fishing efficiency of marine capture fisheries. FAO Fisheries Technical Paper No. 482, 68.

Turenhout, M. N. J., Quirijns, F. J., Taal, C., and Paijmans, A. J. 2014. Factsheet Pulse Fishing. http://www.pulsefishing.eu/sites/pulsefishing.eu/files/pf_research/paper/Knowledgenetwork_Factsheet_Pulsvisserij_UK_Website.pdf (last accessed 27 July 2015).

Valdemarsen, J. W. 2001. Technological trends in capture fisheries. Ocean & Coastal Management, 44: 635–651.

Van den Berge, H., and De Bruijn, S. M. 2000a. Inventor makes electric fishing gear suitable for seawater: fishing under voltage. Reformatorisch Dagblad. http://www.refdag.nl/oud/weet/000222weet02.html (last accessed 21 July 2015) (in Dutch).

Van den Berge, H., and De Bruijn, S. M. 2000b. Electro trawl seems good alternative for the beam trawl. Reformatorisch Dagblad. http://www.digibron.nl/search/detail/012dd03e6789d6b906e24050/elektrokor-lijkt-goed-alternatief-voor-boomkor (last accessed 21 July 2015)(In Dutch).

Van Ginkel, R. 2001. Inshore fishermen: cultural dimensions of a maritime occupation. *In* Inshore Fisheries Management, pp. 177–193. Ed. by D. Symes, and J. Phillipson. Springer, The Netherlands.

Van Marlen, B. 1997. Alternative Stimulation in Fisheries. Final Report for European Commission, 1–190.

Van Marlen, B., Wiegerinck, J. A. M., van Oss-Koomen, E., and van Barneveld, E. 2014. Catch comparison of flatfish pulse trawl and a tickler chain beam trawl. Fisheries Research, 151: 57–69.

Van Slooten, P. L. 2007. Fishing with the pulse trawl: towards a sustainable fishery. Visionair, Knowledge of Fishing, 5: 12–15 (in Dutch).

Vanden Broucke, G. 1973. Further investigations on electrical fishing. ICES C.M. 1973/B: 14.

Visserijnieuws. 2006. Meeting Steering Group, Verburg and a group of fishermen; Possibilities for introduction pulse trawl [online]. http://www.visserijnieuws.nl/nieuws/achtergronden/6730-.bijeenkomst-.stuurgroep-.verburg-.en-.groep-.vissers.html (last accessed 30 October 2014) (in Dutch).

Visserijnieuws. 2008. New subsidies for crew and pulse trawl: opening decision [online]. http://www.visserijnieuws.nl/nieuws/6268-openstellingsbesluit.html (last accessed 30 October 2014) (in Dutch).

Visserijnieuws, a. 2010. Far too many requests pulse fishing [online]. http://www.visserijnieuws.nl/nieuws/7225-veel-teveel-aanvragen-pulsvisserij.html (last accessed 30 October 2014) (in Dutch).

Visserijnieuws b. 2010. Bleker satisfied with agreement Fisheries Council: additional exemptions for pulse fishing [online]. http://www.visserijnieuws.nl/nieuws/7312-extra-ontheffingen-voor-pulsvisserijbleker-tevreden-met-akkoord-visserijraad.html (last accessed 27 July 2015) (in Dutch).

Visserijnieuws. 2011. Commission proposal before the summer: Brussels thinks about admission pulse trawl [online]. http://www.visserijnieuws.nl/component/content/article/70-archief-2011/7755-brussel-denkt-over-toelating-pulskorcommissievoorstel-voor-de-zomer.html (last accessed 27 September 2014) (in Dutch).

Visserijnieuws. 2012. Invitation to discuss criticism and questions: hotline pulse fishing open [online]. http://www.visserijnieuws.nl/nieuws/7818-meldpunt-pulsvisserij-openuitnodiging-om-kritiek-en-vragen-te-bespreken.html (last accessed 10 December 2014)(In Dutch).

Visserijnieuws. 2015. Resistance against the pulse trawl grows in Europe; Pulse demonstration day in Scheveningen with pro- and opponents [online]. http://www.visserijnieuws.nl/nieuws/9140-tegenstand-puls-groeit-in-europa.html (last accessed 23 July 2015) (in Dutch).

Wilson, D. C. 2009. The Paradoxes of Transparency: Science and the Ecosystem Approach to Fisheries Management in Europe. University of Amsterdam Press, Amsterdam. 19–34 pp.

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