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PROJECT REVIEW MEETING OF THE SCIENTIFIC TEAM LEADING THE PULSE FISHERIES PROJECT WITH THE INTERNATIONAL SCIENTIFIC ADVISORY COMMITTEE

Friday 26/01/2018

Ministry of Agriculture, Nature and Food Quality
Bezuidenhoutseweg 73, the Hague
Tinbergenzaal / Meeting Room 52

Attendees: [redacted]

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Narrative of introductory elements

[redacted] *welcomed the participants and thanked them for preparing the summary reports and presentations. He outlined the process by which the International Science Advisory Committee would generate its report. The report would be circulated to the scientific workpackage leaders for verification of the factual content of the report.* [redacted] *of the Dutch Ministry then gave an overview on the development of the European Commission proposal for reformed regulation on technical measures and how these measures relate to the pulse trawl fleet. He explained how the plenary vote in European Parliament had evolved with almost two thirds of MEPs voting against the Commission's proposal, apparently mostly focussing on the rules for using electric current in fisheries, which is only a tiny part of the proposed regulation. The EU parliament opted for a total ban on fishing with electricity (note this would affect all forms of fishing with electricity not just the beam pulse trawl fleet). The next step is the* *trilogue (between the Council, Commission and Parliament) during which negotiations will occur among member states regarding different elements of the proposal for reform of technical measures.*

[redacted] *reflected on his experience of participating in the information event convened by Mr Van Dalen MEP that focused on pulse fishing on the evening of the 15th January 2018 just prior to the debate in the Parliament plenary. It was clear that despite an open invitation to MEPs this was poorly attended with only ~4 MEPs attending. In addition, the discourse in the plenary debate was worryingly supported with evidence that was factually incorrect or reported out of context with few MEPs offering a balanced perspective. Given this experience,* [redacted] *emphasised the importance of clarity and simplicity in reporting of the forthcoming scientific findings arising from the project, as it was clear that only statements easily understandable to a wider public were likely to have an impact on a non-scientific audience.*

Report of the ISAC on the science

Workpackage 1

This workpackage focuses on modelling the effects of electric stimulation on marine organisms. The workpackage uses a combination of controlled laboratory studies and field observations of damage that occurs in fish sampled aboard trawlers.

The researchers aim to develop a model that will explain the observed damage to organisms as seen in the fishing trials. The project aims to answer the question; 'how do fish interact with the electric field of the pulse trawl?'. This model will enable the calculation of an approximation of the amount and proportion of fish, either in the catch or that remain on the seabed, that are likely to experience some form of damage as a direct result of interaction with the electric field generated by the pulse trawl. In order to develop the model the researchers will explore the effects of parameters such as fish size, shape, type of skeleton etc. The project will also examine responses of invertebrates such as whelks that are important commercially exploited species.

The researchers reported that they will be able to measure the response to repeated exposure to electric stimuli over short, but not longer time periods (hours to days). Anything beyond that can only be estimated based on extrapolation It is useful to answer this question because this is directly relevant to management e.g. if a certain threshold in the frequency of exposure to electric stimuli was detected this could be mitigated by implementation of limits to the frequency of fishing in a particular area within a specified time frame (day, week, month). The ISAC noted that although such a management approach is feasible given current technology such as VMS, there remains the question as to whether management authorities have the resources or willingness to undertake such management. It should be noted that this research will address some of the questions raised by the wider stakeholder group (see Annex with stakeholder questions).

The researchers reported a first, preliminary set of measurements in which they establish fish sensitivity to electrical pulses in controlled tank stimulation experiments. Sensitivity is measured as a threshold pulse amplitude (in Volts/m) in a heterogeneous field, at the location of the fish. These results can be used to parameterise the data for the proposed model. Initial trial experiments have been undertaken with anaesthetised Atlantic salmon and bass which indicate that the threshold of stimulation is related to fish size, and in particular the width of the fish at the location of stimulation. Tank experiments show that it is possible to model the electric field in relation to the amplitude of the electric stimulation. For salmon there is relationship between the width of the body, such that larger fish have a lower threshold for stimulation. Regular experiments on a wider range of relevant species have not started because the approval of the ethics commission regarding the final experimental procedures is still pending.

Once ethical approval has been granted, measurements of the thresholds for responses in fish will be complemented with measurements of the three-dimensionsal electric field between the electrodes, in the presence and absence of a fish.These experiments should enable the researchers to determine the main fish properties that dictate the likelihood of responsiveness. Additional studies of skin conductivity and other factors that may affect the response of organisms to electric fields will be undertaken.

Electro-sensitive fish may be attracted to the pulse fishing gear. The behaviour of both electro-receptive and non-electro-receptive fish in relation to electric stimuli will be studied for fish swimming in a large tank. Fish will be stimulated in a stardardized protocol to measure the minimal strength of the electrical fields to induce a behavioral response. Behavioural responses will be filmed using high speed cameras recording normal turning rates, directionality and then record the response of the fish to stimulation and compared to control situations with no electrical stimulation.

Field observations are being undertaken using the pulse gear with the electric pulse switched on and with the electric pulse switched off. In this way, the researchers can isolate the effect of the electric stimulation on fish caught compared with the physical impact of any towed gear on fish caught in the fishing gear. The field studies have quantified the occurrence of any injuries in relation to length and species identity. However, the ISAC noted that the there was no plan in the study to do similar measurements to compare the same metrics of the traditional tickler chain beam trawl versus pulse trawling. The ISAC strongly recommended that this comparison would add great value to the overall study but noted that this may require additional resource to employ enough people short term to enable this to happen. Initial observations with pulse on/off suggests relatively little difference for some species but not for others. Hence the response of fish is species specific. The ISAC noted that the researchers were collecting very detailed data from direct examinations of fish caught at sea of exactly where within the fish the injuries occur. Injuries in the tail area, as occurs for most of the whiting investigated, may indicate a mechanical impact rather than an impact of electric fields. Some fish like gurnard only show spinal injuries when the pulse is turned on, however all gurnard passing into the net and landed on deck are likely to die from barotrauma. Results suggest that sandeels may be vulnerable to injuries caused by electric fields. Whether these injuries result from electrical pulsing of from mechanical trauma requires further examination. These experiments are planned in cooperation with ILVO in Oostende. Some of the general results showed that vessel characteristics (which might relate to slight variations in pulse trawl settings, or potentially some other vessel related variable e.g. size, engine power) was a significant covariate, hence observations from a wider range of vessels would help to understand the amount of inter-vessel variability in these results.

Recommendations WP1:

1. The ISAC would like further written clarification of how the laboratory tank trials on the identification of stimulation thresholds feed into and inform the proposed model. The relationship between a "stimulation" that is visible on the fish, and an agonistic reaction that would make it more catchable, and also may cause injuries, is not obvious. It is suggested that the hypothesis being investigated, and how it links to the core question of whether pulse or tckler chain beam trawls are more environmentally friendly.

2. The field observations of injuries to fish should ideally include a comparison to traditional tickler chain beam trawling. This may require additional resources. The question that needs to be answered within this project has to be "Is the pulse trawl "better" than the beam trawl?". This could be in terms of injured uncaught

fish, damage to benthic organisms and habitat, or changes in the biogeochemistry. This needs to be a "red thread" running through all of the work, and applies to both WP1 and WP2.

3. While it is understood why the tank trials use anaesthetised fish, this raises the question of whether the observed responses are affected by this experimental approach. Anaesthtics are used in medecine to both avoid pain, and to prevent the patient moving during a procedure. It may then be the case that the anaesthtics may also affect the threshold at which the fish responds. So, it may take a higher exposure to the electric field to initiate a response in an anaesthetised fish versus a non anaesthetised one. This should be checked if it is ethically possible.

4. Tank experiments with sandeels are suggested to understand better the response of sandeels to the stimuli generated by the pulse trawl.

5. While the results were understandable to a scientific audience, consideration is needed to simplify the presentation of the results so that they can be more easily assimilated by a non-expert audience while reducing the possibility for misinterpretation.

Work package 2

This workpackage examines the effect of pulse fishing on the benthic ecoystem and the ecosystem services (biogeochemical cycling) provided by sediment fauna. The project has measured a number of parameters including e.g. biogeochemical measurements and oxygen consumption. The project has already measured the in situ effects of pulse and conventional beam trawling on the benthic ecosystem in grounds that are subject so some level of fishing disturbance. The project is also looking at how pulse stimulation affects sediment nutrient cycling. The final phase of this workpackage will compare the effects of pulse trawls with either the electrical stimulation turned on or turned off, and this will occur in June 2018. ISAC noted that the title for this sub-workpackage ("long-term effects of fishing") was probably not describing the aim optimally, and suggested to change the title to something like "The effect of pulse trawling on an undisturbed seabed environment". These trials will occur in a marine reserve from which trawling with bottom gear has been excluded for 2 years. The study has already undertaken incubated box cores from areas fished with the different types of trawlers, measuring oxygen microprofiles and examined sediment and biogeochemical cycles. Each box was trawled 1.5 times to ensure complete coverage. Box corers and landers were used to collect samples and measurements from within the fished areas using a Before/After experimental approach.

Results indicated that there was a much bigger difference in the reduction of Chlorophyll a (= food for benthic organisms) in the surface layers of the sediment for tickler chain fisheries versus pulse trawls. The experimental period also coincided with some storm activity which provided insights on the level of natural disturbance from storm events which could be compared to the effects of the different trawling activities. A reduction in oxygen consumption post trawling was measured for both types of trawl, but this response was more consistent and stronger with tickler chain fishing cf pulse trawling. The ISAC concluded that the results make sense in terms of what we understand from other studies reporting on how bottom towed gear interacts with the seabed. The more uniform effect of tickler beam trawls is entirely in line with expectations given that chains will have a very even impact on the seabed, whereas pulse anodes present a much smaller surface of impact which may explain the greater variability in the results.

Experimental mesocosm cores that were exposed to electrical stimulation (using anodes) were compared to cores mechanically disturbed to simulate tickler chains. The physical disturbance for simulated tickler disturbance was much greater as would be anticipated. The researchers indicated that they still needed to see if there was an effect of electrolysis. Nevertheless, the impact of electrical stimulation on the measured response variables (oxygen consumption and compounds such as nitrate/nitrite) did not appear to be significant (subject to statistical tests).

Recommendations WP2:

1. For the measurements undertaken in the experimental areas where fishing still occurred, the ISAC recommends determining what frequency and intensity of fishing has occurred in these areas as this information would be available through VMS. From the latter, it is possible to calculate when the last fishing events (and what intensity) occurred in the experimental area. The research team in WP2 will need to liaise with IMARES to have access to these calculations or data.

2. The ISAC recommends that before the research team commits to the design of the summer experiment that it seeks advice on experimental design. It is important to optimise the experimental design given the limited sampling time available in the summer field period.

3. It was not clear to the ISAC why the team are not looking at the tickler chain comparison during the sub-workpackage on the effect of pulse fishing on an undisturbed environment, given that the over-riding question in this project is 'is pulse trawling less environmentally impacting that tickler beam trawling?'. The ISAC understands why the research team want to parse out the electric vs net effect, but the ISAC feels that examination of the tickler beam trawl effects is still valuable. The ISAC appreciates this may need more ship time to execute.

Workpackage 3

This workpackage will integrate the work from WP1 and WP2 together with a fleet dynamic module which reproduces the behaviour of the fleet. A well-tested dynamic state variable model will be utilised. The model can be used to look at the association with habitat of the two different gear types as it may be that the new gear has access to a wider (or narrower) range of habitats than the tickler chain beam trawl. The model will be parameterised for catch efficiency and size selectivity. Following an analysis of the data from the observations made from industry vessels, this data shows that the catch efficiency (kg/hour) for sole is ~30% higher in pulse c.f. tickler beam trawls, but is ~40% lower for plaice. This means that the sole quota should be able to be fished by spending less time at sea which would reduce the footprint of the fishing fleet on the seabed. However, no significant reduction in the effort of the pulse trawl fleet has been observed in the recent past, which needs an explanation. The analysis showed that the fine-scale distribution of fishing activity was stable and predictable. The idea is then to integrate this information into the model and then in this way work out the overall effect of pulse trawling for the different sediments across the North Sea.The model will factor in the additional effects of injuries and mortality of bycatch species such that a more complete picture of the effect of pulse trawling can be derived.

Preliminary results demonstrate that, with reduced mean penetration depth of the gear into the substrate (2 cm in pulse vs 5 cm in tickler chain) and reduced towing speed (5 kn in pulse vs 6.5 kn in tickler chain beam trawls), the overall benthic impact seems to be reduced to about 50% of the impact in 2009.

Recommendations WP3:

1. The ISAC considered that it would be good to understand more about the amount of time being spent fishing considering that the quota uptake appears to be achievable in far less time (than appears to be utilised at present) due to the greater efficiency of the pulse trawl. This of course has implications for the amount of discards.

2. ISAC recommends that when scaling the results of the workpackage to the total North Sea, legal limits as for the present beam trawls should be assumed (i.e. no fishing with beam trawls north of 55°N)

Workpackage 4

This workpackage involves the integration of the different parts of the programme, and as such has not begun. The ISAC had several suggestions for consideration.

Recommendations WP4:

ISAC recommends to explore the potential to optimise the gear for more than just fuel consumption, i.e. could the models be used to understand better the relationship between reduced fuel consumption vs reduce environmental impact vs reduced bycatch vs increased catch such that an optimisation analysis could be undertaken? The required changes to the gear might be minimal (such as different pulse characteristics or altered insulation of the electrodes to limit the effect of the electric field to the immediate vicinity of the sea floor)

Additional studies

The primary rationale for pulse was fuel saving and reduced bycatch. But what do fishermen think about reduction of benthic impacts? The lack of consideration of the social aspects of pulse trawling has undoubtedly led to problems in the current debate. In order to address some of this shortfall the following recommendations for additional studies are made:

1. The modelling has not incorporated social interactions, e.g. interactions with other competing metiers. Such an analysis would be useful to inform management, even if an initial GIS exercise to examine the overlap between different gear metiers was the limit of the analysis.

2. The research team should explore the extent to which it is possible to examine social and economic aspects of the pulse trawl fishery, perhaps focusing on three MSc student led studies in Holland, the UK and France. The purpose of the studies would be to understand fisher perceptions and attitudes towards pulse trawling and to explore the limits of accepability and parameters around this that might lead to a more consensus based view of the efficacy of using pulse trawling (or other new innovative fishing gears).

[redacted] agreed to help the research team frame this problem further if this would be beneficial.

Annexes:

Annex 1 - Brief reports
Annex 2 - Papers and abstracts
Attachment - Stakeholder priority question list with scientist self-assessment
Attachment - Presentations

Annex 1 – Brief reports

Workpackage 1 - Title of the area of research:
Modelling the effects of pulse stimulation on marine fish and invertebrates

Please give the main bullet objectives of the research (150 words maximum)

1. A model-framework for simulating spatio-temporal characteristics of electrical fields generated by pulse fishing gear in different environments.
2. A model-framework for linking external electrical fields to internal current flow in animals differing in size, shape and electrical properties. Fine tuning of the model frame work depends on data gathered in experiments that will be done in cooperation with Flanders Institute for Agricultural and Fisheries Research (ILVO) and Wageningen Marine Research (WMR)
3. Report on susceptibility of marine invertebrates to electrical pulses. Susceptibility concerns both survival and behavioural effects.
4. Report on behavioural responses in different groups of fish, both electroreceptive and non-electroreceptive, to low amplitude electrical pulses.
5. A model framework for numerical simulations of pulse fishing effects; specificity of catches, bycatches and potential collateral damage.
6. Report on damage in target and bycatch species in commercial electrical fishing, on the basis of Xray photographs. This is a combined effort of WMR (field samples) and EZO (X-ray analysis)
7. Summarise the main findings to date relative to the original targets (500 words maximum):

We have changed the order of the steps leading to the final integration. Most importantly, the modelling has been postponed and instead we first started the experimental parts of the project. The experiments require much preparation and development time. To maximise chances for success we therefore started two main experiments (muscle activation experiments and behavioural experiments on fish) early on. In addition, we have gathered many data for the fleet-sampling. The PhD student started his PhD project in August 2016, 8 months after the start of the Impact Assessment Pulse Fishery (IAPF) program.

1. The model is postponed until the second year, after the most challenging experiments have been started. Preparations have started to generate the required models in the COMSOL simulation package.
2. We have finished a first series of pilot experiments in which we have measured the sensitivity of Atlantic salmon (*Salmo salar*) and European seabass (*Dicentrarchus labrax*) (available species) to electrical pulses at different locations along the length of their body, and for different fish sizes. Hereto we developed an anesthesia protocol. So far, muscle activations were scored visually. We will investigate whether it is possible to measure this by means of electromyography. The setup for these measurements is up and running. Further experiments require Experiments on Animals Act approval. The animal experiments application has been submitted and we expect to get a green light by the start of March or April.
3. Experiments on marine Invertebrates will be planned from the fall of '18 onwards, in cooperation with ILVO in Ostend.

4. We are currently finishing the final preparations for the behavioural experiments. We developed a real-time video-tracker that can track swimming fish 'on the fly'. This allows us to generate stimuli depending on the location and orientation of the fish relative to the stimulation electrodes. We have developed a fully programmable stimulus generator in which all parameters are under software control. Once the ø2.5 m tank is installed we will be ready for pilot experiments. The system is set up to run experiments fully automatically, logging changes in swimming behaviour due to each stimulus presentation.
5. See 4, we have small-spotted catshark (*Scyliorhius canicula*) available for the first set of measurements. Thornback ray (*Raja clavata*) are expected to arrive later in February 2018.
6. See 1. This part of the modelling builds on the models generated for objective 1 and 2.
7. We have made good progress in collecting samples from pulse fishing trips and analysing damage using X-ray imaging. Thousands of fish have been X-rayed and entered into a custom-developed data-base program. The program allows us to score damage (type and severity), and to indicate the location of the damage. We now have a good overview of damage observed in different species, and for some species also sufficient data to investigate a fish length effect. We have very limited data to compare pulse-on hauls to pulse-off hauls, and no data to compare to tickler chain trips. Both controls have our full attention.

Summarise the remaining targets (500 words maximum):

1. A first report/manuscript will concern the size dependency of damage observed in samples from pulse fishing trials. This requires additional data for cod, to increase the statistical power for a size effect. The PhD student will join fishing trips to collect additional samples. At the same time, he will be able to collect live fish for behavioural experiments (preferably gurnards; their survival rate is, however, unknown and collecting possibility depends on other factors as well).
2. A second report will concern an assessment of overall damage observed in different species, and possible morphological factors of influence. The scope of this manuscript will benefit much from a more extensive comparison between pulse – no-pulse trials (and tickler chain) trials. These experiments are not included in the IAPF proposal and would require additional efforts. Steps have been taken to organize data collection for both no-pulse and tickler chain controls.
3. Experiments on muscle activations await Experiments on Animals Act approval, and availability of fishes.
4. See above
5. Behavioural experiments with small-spotted catshark without electrical stimulation to check the hardware and software can start within about one month. Experiments including electrical stimulation must await Experiments on Animals Act approval. Whether we can use other fish species depends on availability and housing feasibility. We have a MSc student interested to perform these experiments.
6. See above
7. A final set of X-ray photographs needs processing to complete the data set. Some new samples will be collected and analysed in the next few weeks. The final conclusion will be much stronger if we could also include comparisons to non-pulse and tickler chain hauls/trips.

Workpackage 2 - Title of the area of research: Differential effects of electrical pulse and conventional beam trawl fisheries on sediment biogeochemistry

Please give the main bullet objectives of the research (150 words maximum):

1. Conduct a field study in cooperation with the Netherlands fishing sector comparing the short term impacts of electric pulse trawling and conventional beam trawling on the benthic ecosystem.
2. Conduct a field study in cooperation with Wageningen Marine Research (WMR) and Rijkswaterstaad experimentally assessing the immediate effects of electrical stimulation and physical perturbations on benthic biogeochemical parameters.
3. Conduct a field study in conjunction with the Netherlands fishing sector and Flanders Institute for Agricultural and Fisheries Research (ILVO) assessing the long-term effects of electric pulse trawling on the benthic ecosystem.
4. Create predictive mechanistic models on how ecosystem functioning is affected by pulse trawling and tickler chain trawling.

Summarise the main findings to date relative to the original targets (500 words maximum):

1. The only major deviation from our research from the original Tender document is that Task 2.1 (Field campaign 1. Experimental assessment of the short-term effect of pulse stimulation on the sedimentary nutrient cycle) was postponed for one year as the equipment needed for this study was not yet available, the planned cruise sailed in unfavourable locations and the PhD student (J[redacted]) was hired 4 months after the official start date of the Impact Assessment Pulsetrawl Fishery program. The manuscript for task 2.1 is now set to be delivered in the second quarter of 2019, while the manuscript for task 2.2 (Field campaign 2. In situ effects of pulse and beam trawling on the benthic ecosystem) is expected to be completed in the second quarter of 2018 (originally expected in the fourth quarter of 2018 in the tender document).

2. Field campaign: *In situ effects of pulse and beam trawling on the benthic ecosystem*, was carried out in June 2017 on the NIOZ RV Pelagia. During this research cruse, we were supplied with a commercial beam trawler and a commercial pulse trawler from VisNed and the Nederlandse Visserbond respectively. These vessels were able to able to successfully create experimentally fished areas of the same fishing intensity in (similar to Depestele et al. 2016) in the Frisian Front location of the North Sea. We subsequently collected data to compare and contrast the impact of the two fishing methods on biogeochemical properties such as the consumption of oxygen and the fluxing of nutrients. A strong wind storm occurred nearing the end of the research campaign which provided us the opportunity for a "natural disturbance" type of treatment. Data from this study suggests that beam trawl fishing has a larger and more consistent impact on sediment oxygen dynamics than pulsetrawling. Similar to the bathymetrical results of the BENTHIS study (Depestele et al. 2016), the effect of pulse fishing showed more variablility between the two gear types. There is still data in this study which needs to be processed, however, the first manuscript from this research will be available towards the middle of 2018.

3. Field campaign: *Experimental assessment of the short-term effect of pulse stimulation on the sedimentary nutrient cycle,* began in September of 2017 on the Rijkswaterstaat RV Tridens. This research took place during WMR's annual beam trawl survey (BTS). Intact sediment samples were taken from various locations across the central North Sea and were subjected to either physical or electrical stress. The purpose of this research was to examine and compare the immediate potential effects of electric pulse and beam trawl fishing in a controlled laboratory

setting and shed light on potential impacts of electrolysis in different sediments. So far, the study suggests that the effects of electricity compared to any physical disturbance appear quite limited.

4. A predictive mechanistic model on how pulse/beam trawl fishing affects benthic pelagic coupling has been created, partially fulfilling task 2.4 (Development of mechanistic biogeochemical models). This model will eventually be upscaled to feed in to workpackage 3 (Sea bed: scaling up the effects of pulse trawling to the North Sea level). The model still needs data from ongoing field campaigns in order to adjust it to realistic levels.

List any papers or reports published:

[redacted] Comparing the impact of pulse fishing and beam trawling on oxygen and nutrient fluxes. In preparation

Workpackage 3 - Title of the area of research: Sea bed, scaling up the effects of pulse trawling to the North Sea level

Please give the main bullet objectives of the research (150 words maximum):

1. Develop a predictive model of the distribution of pulse trawl and beam trawl vessels in relation to the density of their target species and the distribution of sea bed habitats
2. Develop a predictive model of the impact of pulse trawling and beam trawling on the benthic ecosystem
3. Estimate the proportion of the catch of pulse trawls that is injured by the exposure to electrical stimulation

Summarise the main findings to date relative to the original targets (500 words maximum):

1. This task will adjust the fleet dynamic model of Poos et al (2007) and Batsleer et al (2013) to predict the effort distribution at a course spatial scale. In order to downscale the fishing effort at the scale of the gear we need to know how the trawl effort is distributed within these larger spatial areas. To provide a scientific basis for this downscaling, a statistical analysis was carried out of the fine scale distribution of fishing effort (within ICES rectangles). Assuming that fishing effort has a negative binomial distribution, allowing for over dispersion, the results show that the distribution is stable in time despite changes in the total effort by ICES rectangle. For each rectangle, the overdispersion parameter estimates the proportion of untrawlable grounds. A second analysis was carried out to study the habitat preferences of the pulse and the beam trawl. Results of both studies will be used to downscale the predicted effort at a larger spatial scale predicted by the fleet dynamic model
2. Data collected in BENTHIS have been further analysed to estimate the penetration of the pulse trawl and tickler chain beam trawl in the sea bed. The results are required to apply the impact method developed in BENTHIS. A paper is in preparation (Depestele et al, in prep).
   The impact on the benthic ecosystem have been estimated using the longevity and population dynamic approach (PD2). The PD2 method is particularly useful as it allows us to take account of the reduced penetration depth of the pulse trawl as compared to the tickler chain beam trawl. The PD2 indicator decreased by about 50% in the period 2009 – 2016 due to the vessels switching from the traditional beam trawl to the pulse trawl. The decrease in impact relates to the impact of the sea bed disturbance generating additional mortality among benthic organisms but does not take account of additional mortality (if any) imposed by electrical stimulation. Results were presented by Hans Polet at the 10th international flatfish symposium, St Malo, November 2017.
   When the results of WP1 and WP2 becomes available, the impact analysis can be extended by including the impact of electrical stimulation.
3. Data collected during a fleet survey where a beam trawl and a pulse trawl vessel were fishing a number of stations were analysed to estimate the catch efficiency and selectivity of the pulse and the beam trawl gear. A paper is in preparation (van der Reijden et al).
   In collaboration with the parallel logbook project, catch data by trip of pulse and beam trawl vessels were analysed to estimate the change in catch efficiency of vessel switching from the beam trawl to the pulse trawl. Preliminary results show a significant increase in the catch

efficiency for sole and a decrease for plaice. Results have been presented by [redacted] at the 10th international flatfish symposium (St Malo, November 2017).
The results on catch efficiency and selectivity are required to model the distribution and impact on marine organisms (fish, benthos).

List any papers or reports published:

Hintzen, Aarts, Rijnsdorp. How stable are fishing grounds in space and time? In preparation

Depestele, Degrendele, Esmaeili, Ivanovich, Kroger, O'Neill, Parker, Polet, Roche, Teal, Vanelslander, Rijnsdorp. Reducing acute bottom trawling impacts in soft sediments by replacing mechanical for electrical disturbance. ICESJMS in prep

Summarise the remaining targets (500 words maximum):

1. Fleet dynamic model will be adjusted to be used to predict the spatial distribution of the pulse trawl and beam trawl. FD parameters need to be updated, model scenarios determined. FD results needs to be coupled to the downscaling methods to produce trawling intensity data by grid cell to be used in the impact assessment.
2. Trawling intensity maps will be overlaid with maps of the benthic ecosystem and the impact will be estimated. Algorithm to convert trawling intensity to a benthic impact will be provided by WP2 and based on results from BENTHIS.
3. Trawling intensity maps will be overlaid with maps of the species / species group of interest and the impact will be estimated (%injured fish; discard bycatch). Algorithm to convert trawling intensity to a lesion probability will be provided by WP1. The bycatch estimate will be based on the parameterisation of the species selectivity and size selectivity information. Specific attention will be given to Elasmobranchs.

Workpackage 4 - Title of the area of research: Impact Assessment

Summarise the main findings to date relative to the original targets (500 words maximum):

This work has not yet started

Summarise the remaining targets (500 words maximum):

1. The fleet dynamic model developed in WP3 will be used to predict the spatial distribution of fishing effort of the Dutch fleet targeting sole using either the conventional beam trawl or using the pulse trawl. This will be done at the scale that is appropriate to estimate the impact of both gear types on the benthic ecosystem.
2. The sensitivity of the effort allocation patterns for the input parameters will be explored. Effort allocation patterns will be compared to the observed distribution patterns to test the validity of the model predictions.
3. Modelled effort distribution maps will be overlaid with distribution maps of biota to estimate impact for a selection of fish species and benthic invertebrates and maps of benthic functional groups, given the sensitivity of the biota estimated in WP1 and WP2.
4. Expected output (i) population level estimates of injuries for a number of fish species; (ii) estimate of discards in the beam trawl and pulse fishery when harvesting the available sole quota; (iii) estimate of the impact on the benthic ecosystem functioning.
   The above results will be integrated with results from other relevant studies which have been conducted in parallel with the current project.

Annex 2 – Abstracts of papers or other outputs

Reducing acute bottom trawling impacts in soft sediments by replacing mechanical for electrical disturbance

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Abstract

Ecosystem-based management strategies increasingly require assessments of bottom trawling impacts on benthic habitats at the detailed level of different gear types. The mitigation potential of replacing mechanical by electrical stimulation to catch flatfish was examined by combining several modelling and observation techniques to assess the reduction in trawl penetration and associated effects on the seabed texture and sediment sorting. The penetration depth (mean, SD) of the tickler chain trawls (4 cm, 0.9 cm) and pulse trawls 1.8 cm, 0.8) was estimated by measuring the depth of the disturbance layer and by modelling the erosion of the surficial sediments due to sediment mobilisation in the wake of the gear (tickler-chain = 0.6 cm; pulse trawl = 0.8 cm). Sediment Profile Imagery (SPI) showed that tickler-chain trawls homogenized the sediment deeper (3.4 cm, 0.9 cm) and removed the oxygenated layer more than pulse trawls (1 cm, 0.8 cm). Numerical modelling predicted that tickler-chain trawls penetrated deeper into the sediment than pulse trawls. Particle size analysis suggested that pulse trawling only caused a coarsening trend towards the top layers (winnowing effect), while tickler-chain trawls additionally injected finer particles into the deeper sediment layers (~4 cm depth). Bathymetrical measurements using a multi-beam echosounder (MBES) confirmed that the tickler-chain trawl tracks were consistently and uniformly deepened to 1.5 cm depth in contrast to 0.7 cm following pulse trawling. MBES backscatter strength analysis suggested that tickler-chains trawls (3.11 dB) also flattened seabed roughness significantly more than pulse trawls (2.37 dB). The reduced pulse trawling impacts allowed a faster re-establishment of the oxygenated layer and micro-topography in contrast to tickler-chain trawling.

Keywords: beam trawl, biogeochemistry, particle size distribution, penetration depth, pulse trawl, seafloor integrity, sediment resuspension

Funding: FP7-BENTHIS and Impact Assessment Pulse Trawl Project (ADR, LRT)

How stable are fishing grounds in space and time?

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Abstract

High resolution vessel monitoring (VMS) data have led to detailed estimates of the distribution of fishing in both time and space, showing the typical fishing grounds on a yearly basis. While several studies have documented the large-scale changes in distribution of fishing and their overlap with targets species, fine-scale patterns are still poorly documented, despite the ability of the VMS data to allow for such analysis. Defining a mechanism that explains with predictive power the behaviour of fishers at fine spatial scales is needed to address the impact bottom trawling has on the ecosystem. The objective of this study is to quantify the extent to which fishing grounds are stable at a micro-scale (tens of meters) by studying the distribution and level of aggregation of fishing within the management fishing unit of an ICES rectangle (one longitudinal degree by ½ a latitudinal degree). The model links effort registered at the ICES rectangle scale to fine spatial trawling intensities at the local scale fishing takes place (i.e. scale matching gear width, here 24m). Furthermore, the model predicts the part of an ICES rectangle that is unfavourable or inaccessible for fisheries. Time-series analyses are executed to test whether aggregation, the proportion unfavourable or inaccessible for fisheries and the exact spatial location of fishing activity changes over time. The Dutch beam trawl fleet, operating heavy beam trawls targeting sole and plaice in the southern North Sea, is used as a case study. The results show that aggregation, unfavourable / inaccessible grounds and spatial location of the fisheries are estimated with large stability over time, suggesting that fishing grounds are stable in space and time. The method developed provides a mechanistic model to predict trawling impact at small spatial scale from effort registered at the larger fisheries management unit.

Keywords: Beam trawling, benthic impact, effects of trawling, North Sea, unfavourable habitat, inaccessible habitat, VMS

Oral presentation 10th international symposium on flatfish ecology

St Malo, 11-16 November 2017

CAN PULSE TRAWLING REDUCE THE MECHANICAL IMPACT ON THE BENTHIC ECOSYSTEM IN THE BOTTOM TRAWL FISHERY FOR SOLE?

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Abstract

In the beam trawl fishery for sole in the North Sea, the twin beam trawl has dominated the fishery since the 1960s. Beam trawlers used heavy gear with tickler chains to chase sole out of the sea bed. The fishery is criticised for the mortality imposed on benthic invertebrates, the adverse effects on the sediment structure and on the high energy consumption. Since 2010, a number of vessels has switched to the economic more profitable pulse trawling technique which uses electrical stimuli to immobilise the target species. Because electric fishing is illegal in the EU, the pulse trawlers operate under a temporary derogation. In this paper we present the results of the recent studies to the effects of pulse trawl and tickler chain beam trawls on the benthic ecosystem carried out in the FP7-project BENTHIS. We compared changes in infauna in two controlled fishing experiments with a commercial tickler chain and pulse trawl, measured the penetration depth of the gear using multi-beam and sediment profile imaging. The empirical results are compared to model estimates of the penetration and sediment re-suspension. Finally, the results are integrated in a recently developed quantitative framework to assess the impact of bottom trawls on the benthic ecosystem.

http://www.flatfishsymposium.com/files/layout/Presentaties/powerpoints%20wednesday/presentation-polet-nov-15.pdf

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DATE
February 27, 2018

SUBJECT
Preliminary assessment of the reduction of the ecological and environmental impacts of the tickler chain beam trawls by pulse trawls in the North Sea fishery for sole and plaice

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Preliminary assessment of the reduction of the ecological and environmental impacts of the tickler chain beam trawls by pulse trawls in the North Sea fishery for sole and plaice

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Introduction

This report provides a preliminary assessment of the potential contribution of pulse fishing to the sustainable exploitation of flatfish with a reduced environmental and ecological impact as compared to the traditional beam trawl fishery with tickler chains. The report is commissioned by the Dutch ministry of Agriculture, Nature and Food Quality (LNV) after the decision by the EP to ban pulse trawling.

The assessment evaluates the scientific knowledge on the relative impact of both fishing methods on a number of environmental, ecological, and fisheries management criteria, and evaluates the strength of the scientific evidence and its uncertainty. The assessment is based on the review and synthesis of the scientific knowledge by ICES WGELECTRA in January 2017 (ICES, 2017b) and additional information that has become available in 2017 (Desender, 2018; van der Reijden et al., 2017; Polet et al., 2017).

In addition, the Bloom document (Bloom, 2018) on pulse fishing, which was presented to the members of the European parliament in early January 2018, is reviewed.

Assessment

The pulse trawl is an alternative fishing method that can replace the tickler chain beam trawl targeting flatfish in the North Sea. The pulse trawl is particularly selective for sole. To assess whether the pulse trawl is an innovation that improves the sustainability of the flatfish fisheries, a number of criteria needs to be assessed (Table 1). The criteria chosen are based on the concerns expressed by stakeholders on possible adverse effects of pulse fishing on the marine environment and on the general concerns about the adverse effect of bottom trawls (Kraan et al., 2015; Kaiser et al., 2016). For each criterion, the scientific literature is reviewed for evidence that the pulse trawl has a lower, similar or higher environmental impact. The strength of the evidence is assessed as proven, indicative or inferred. The uncertainty is scored as low, medium and high taking account of the relevance of the

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evidence for the sometimes wider criterion. For example, for the criterion 'marine organisms' experimental studies showing no adverse effect on one species will score a medium uncertainty.

Table 1 presents the score card summarising the assessment of the scientific evidence for the different criteria. Below the results are summarised.

Catch comparison experiments show that the pulse gear is more selective in catching sole relative to plaice and other bottom dwelling fish species (van Marlen et al., 2014). Ongoing research provided evidence that the pulse trawl has a higher catch rate for sole, but a lower catch rate for plaice than the tickler chain trawl. The available studies of the size selectivity have not resulted in a clear answer whether pulse trawling reduces the catch efficiency of smaller fish (ICES, 2017b). Nevertheless, the improved species selectivity is expected to result in a reduction in discarding because of the lower catch efficiency of other species relative to sole.

The increase in catch efficiency of sole does not increase the risk of overfishing because the fishing pressure is controlled by the catch quota management. However, increased catch efficiency can lead to a competitive advantage on local fishing grounds that are used by different fisheries (Sys et al., 2016).

In the southern North Sea there has been a relative increase in pulse trawling as compared to beam trawling in the past. Whether this may influence thee spawning-stock biomass (SSB) of the eastern Channel sole stock is unknown. The SSB of North Sea sole has increased since 2007 and has been estimated at above MSY $B_{trigger}$ since 2012. The SSB of eastern Channel sole has been fluctuating between Blim and MSY $B_{trigger}$ (ICES, 2017d; ICES, 2017e).

The lower fuel consumption and the increased catch efficiency for sole have substantially improved the economic profitability of the pulse trawl vessels. Pulse stimulation allows fishers to reduce the towing speed. In combination with the lower weight of the gear, this leads to a reduction in the fuel use and CO_2 emission of 46% (Turenhout et al., 2016), a reduction in the surface area of the seafloor that is trawled (Polet et al., 2017), and a reduction in the wear of the trawl nets and corresponding pollution. Besides, the replacement of tickler chains with electrodes will reduce the disturbance of the sea floor. The penetration of the gear was estimated to decrease from 4.0 cm (beam trawl with tickler chains) to 1.8 cm (pulse trawl) (Depestele et al., 2018). The reduced footprint and penetration depth results in a reduction of the impact on the benthic ecosystem in terms of the biomass of the benthos as well as the community composition (Polet et al., 2017), which will reduce the impact on the functions of the benthic ecosystem such as the bio-turbation and bio-irrigation. The effect of electrical stimulation on the bio-geochemical processes in the sediment is currently being investigated.

Catching leads to the mortality of the marketable fish that are landed. Fish that are caught in trawls but thrown back to sea (discards), or fish that escape through the meshes, may incur injuries and may die. The severity of the damage caused is related to the towing duration, towing speed, catch composition and type of gear used. Pulse fishing imposes less damage of species in the net because of the lower towing speed, lower volume caught and cleaner catch composition. Flatfish caught in commercial pulse trawls have fewer skin lesions and show a better vitality score (Uhlmann et al., 2016). The survival experiments carried out so far show a substantial survival in flatfish discards (sole, plaice, turbot and brill) and in thornback ray (van der Reijden et al., 2017; Molenaar et al., in prep). The survival of sole and plaice discards is higher than the survival reported for the traditional tickler chain beam trawl fishery in the Netherlands (van Beek et al., 1990).

The major concerns about pulse fishing is the fear that exposure to an electrical stimulus may cause unwanted side-effects and mortality of flatfish, roundfish, cartilage fish or invertebrate species (Kraan et al., 2015). Laboratory experiments have confirmed that injuries may occur in some species (de Haan et al., 2016; Soetaert et al., 2016b), although the vast majority of animals experienced no adverse effects during or after exposure to electrical pulses (Soetaert, 2015; Desender, 2018).

So far, no side-effects were observed in flatfish. Sole was exposed to a wide range of electrical stimuli, exceeding the intensities used in the field, showing that none of the soles showed injuries or mortality (Soetaert et al., 2016a). Another study exposing over 100 dab near the electrodes of the pulse used in the sole fishery did not induce harm (de Haan et al., 2015). No injuries were observed in plaice exposed to the pulse stimulus used in the fisheries for brown shrimp (Desender et al., 2016).

Roundfish on the other hand have proven to be more vulnerable, especially gadoid species. Spinal fractures have been observed in cod, both at sea and in laboratory experiments (de Haan et al., 2016; van Marlen et al., 2014; Soetaert et al., 2016b). Other species such as seabass and flatfish do not show these spinal injuries (Soetaert, 2015; Desender et al., 2016; Soetaert et al., 2016a). Given the observed proportion of fractured roundfish (cod 9%; whiting 2%: van Marlen et al., 2014) and the small proportion of these species in the total catch, the number of injured fish in the total catch is likely to be very small. The injuries in marketable fish will affect the value of the fish but will not have adverse ecological effects as these will be landed anyway. For undersized fish, fractures may contribute to the mortality imposed by the catch process. To assess the possible adverse effect, it is important to know whether body size has an effect on the sensitivity. This is currently being investigated.

Pulse stimulation may disturb the sensory system of fish species that make use of electrical stimuli to detect their prey, such as sharks and rays. In a tank experiment, it was found that the capability of catsharks to detect electric prey was not affected by exposure to a commercial pulse stimulus (Desender et al., 2017).

The few exposure experiments carried out so far have not indicated any major adverse effect of electrical pulses on invertebrate species, including brown shrimps, despite repetitive exposures of high intensities (Soetaert et al., 2015; Soetaert et al., 2016c).

Review of the critique of Bloom

A review of the critique by Bloom (2018) against the available scientific evidence is given in Table 2. The Bloom document criticises a number of topics ranging from ecological, fisheries management, governance, legal and political aspects. Table 2 compares all paragraphs of the Bloom document in one column with the relevant factual information focussing on the environmental, ecological and fisheries management aspects in another column. Some of the points raised by Bloom reflect their opinion about industrial and small-scale fisheries. These topics are not reviewed as these opinions are more related to values, objectives in and trade-offs of fisheries governance, than to facts related to pulse fishing. The political and governance related topics are not reviewed as they are beyond the scope of this report.

Conclusion.

Based on the current scientific knowledge available to date, the sustainability score card (Table 1) shows an improvement of most of the criteria. The clear negative effects are related to the injuries caused by pulse stimulation in cod and whiting. On the socio-economic side, the increase in competition between the pulse and other fleets on local fishing grounds is a negative effect for the non-pulse fishers.

The severity of the injuries caused by pulse stimulation appear to be restricted to gadoid roundfish and can be explained by the biomechanical overload of the spinal column. Because no negative effects were found for flatfish, which comprise the bulk of the catch, sharks and invertebrates, the percentage of the total catch that is injured by the electrical stimulation will be small. The incidence rate of lesions caused by the pulse stimulus are likely to be small relative to the incidence rate of lesions caused in the catch process of the tickler chain beam trawl, although the latter has not been investigated in depth. Additionally, a clear reduction in bottom impact, discard rates and fuel consumption has been shown.

The review of the Bloom document shows that their conclusions about the devastating effects of pulse fishing on the marine environment cannot be substantiated scientifically.

The preliminary conclusion can be drawn that based on the available scientific evidence available to date there is no support that pulse trawling will have serious ecological impacts, although a number of important questions are currently under investigation. The ongoing research will critically test this preliminary conclusion by investigating a broader range of fish species (and sizes) and benthic invertebrates, developing a bio-mechanistic understanding of how electrical stimulation cause injuries, and study the effect of electrical and mechanical stimulation on geochemical processes in the benthic ecosystem. The results of these studies will be available for a full assessment in 2019.

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Justification

Project number: 43141000010

The scientific quality of this report has been peer reviewed by a colleague scientist and a member of the Management Team of Wageningen Marine Research

Approved: [redacted]
Researcher

Signature: [redacted]

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Date: February 2018

Table 1. Preliminary assessment of the contribution of the pulse trawl to improve the sustainability of the sole trawl fisheries by reducing the adverse impact on the environment, benthic ecosystem and marine organisms, and the consequences for the sustainable management of commercial stocks and socio-economy. The colour code shows whether the pulse trawl is an improvement (green) or deterioration (red) compared to the tickler chain trawl. The intensity of the colour reflects the degree of support and uncertainty.

	Impact of pulse trawl relative to tickler chain trawl	Strength of support (1=proven; 2=indicative 3=inferred)	Uncertainty 1=low 2=medium 3=high	Comment	Source
Environment					
CO2 emissions	46% lower	1	1	Due to lower fuel consumption	Turenhout et al (2016)
Seafloor disturbance	~50% lower	1	1	Due to lower towing speed and reduced penetration in seabed	Polet et al (2017); Depestele et al (2016, 2018)
Pollution	Reduced	3	1	Due to lower towing speed and lighter gear the wear of the gear is reduced	
Benthic ecosystem					
Impact on benthic biomass	~50% lower	1	2	Due to lower towing speed and reduced penetration in seabed the mortality of mechanical disturbance is reduced	Polet et al (2017); Depestele et al (2016, 2018)
Ecosystem functions	improved	2	2	Logical consequence from the above	
Marine organisms					

	Impact of pulse trawl relative to tickler chain trawl	Strength of support (1=proven; 2=indicative 3=inferred)	Uncertainty 1=low 2=medium 3=high	Comment	Source
Fractures / haemorrhages due to electrical pulse	Increased	1	1	In cod (9%) and whiting (2%) but not in flatfish. The incidence rate is un-certain (small sample size) Cod, whiting relative small proportion of total catch	Van Marlen et al. (2014); De Haan et al (2016); Soetaert et al (2016a, 2016b)
Fractures / haemorrhages due to catch process	reduced	2	2	Lower towing speed and cleaner catch	Uhlman et al (2016)
Skin lesions / scale loss	reduced	2	2	Lower towing speed and cleaner catch	Uhlman et al (2016); Molenaar et al (in prep); van Beek et al (1990)
Discard survival	improved	1	1	Lower towing speed and cleaner catch. Only in roundfish pulse may increase mortality due to spinal fractures (uncertain)	Van der Reijden et al (2017); Molenaar et al (in prep)
Development and growth eggs and larvae	No or small adverse effect	2	2	Experiments with cod and sole	Desender et al. (2017b); Desender (2018)
Mortality of invertebrates	No, or small adverse effect	2	2	Few experiments	Soetaert et al (2015, 2016c)
Behaviour	No effect	2	2	catshark	Desender et al (2017a)
Management of commercial stocks					

	Impact of pulse trawl relative to tickler chain trawl	Strength of support (1=proven; 2=indicative 3=inferred)	Uncertainty 1=low 2=medium 3=high	Comment	Source
Species selectivity	More sole	1	1	Increased catch rate of sole relative to other species	ICES (2017b)
Size selectivity	No effect on size selectivity	2	2	Conflicting evidence from comparative fishing trials	ICES (2017b)
Discards (fish)	Reduction in discards relative per kg sole	3	3	Inferred from higher selectivity of sole	
Discards (benthos)	Substantial reduction	1	1		ICES (2017b)
Risk of overfishing	No effect	1	1	TAC restrict fishing effort NSea flatfish fisheries	ICES (2017d, 2017e)
Socio-economic					
Competition with other fishing fleets	[redacted]	1	1	If fishers exploit the same grounds.	Sys et al (2015); Rijnsdorp et al (2008)

Table 2. Review of the critique of Bloom (2018) on the impact of pulse trawling.

#	Bloom	Scientific evidence
1	Electric 'pulse' fishing is a technological trick which halves fuel consumption, so that a fleet of otherwise cash-strapped fishing units can be kept in operation. Under the guise of "experimental fishing" a whole fleet in the Netherlands has been converted to a fishing method that is banned in Europe (and elsewhere in the world). Several million euros of public money have been allocated to equipping Dutch vessels with electric 'pulse' trawls, with the complicity of the public authorities.	Fuel consumption is reduced by 46% (Turenhout et al., 2016) All pulse trawl vessels collaborate in a research project where the landings of the main commercial fish species are recorded per tow to study the small scale dynamics of their distribution and exploitation of local fishing grounds. This will provide better understanding of the interactions between vessels on a local fishing ground. A total of 84 licenses have been issued in the Netherlands (Haasnoot et al., 2016) of which 79 are currently (pers comm LNV) used: - 22 under a derogation under Annex III (4) of Council Regulation (EC) No. 41/2006 allowing 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; - 20 vessels 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; - 42 temporary licenses in the context of the landing obligation to explore in technological innovations to reduce discarding. According to information obtained from the ministry of LNV, subsidies were given to the 1st four vessels to 40% of the investment with a maximum of €176,000 per vessel. 3.8 million Euros of EMFF have been committed for research projects on the ecological effects of pulse trawling in the fishery for sole and brown shrimps.
2	Reducing costs in a situation of chronic overexploitation is a seductive argument to convince European fishers to equip their vessels with electrodes. Unfortunately, this fishing method is so effective that above all, it promises to accelerate the exhaustion of marine resources and ruin the fishing sector in the medium term.	The pulse vessels target North Sea sole which is exploited according to the MSY target (ICES, 2017). Hence, the total fishing effort of the pulse trawlers is restricted by the annual quota.
3	Accepting electric 'pulse' fishing is an admission of failure: it recognizes that there are no longer	This is an opinion.

#	Bloom	Scientific evidence
	enough fish for fishers to fill their nets without recourse to increasingly sophisticated and effective technology. There is an urgent need to understand the risk associated with the mermaid's song of industrialists, and to say no to the desertification of the ocean, the disappearance of small-scale fishing and the collapse of a whole economic sector	Concerning research of the risk of pulse fishing, the effect has been the subject of scientific research projects including two PhDs at the University of Gent (Soetaert, 2014; Desender, 2018), two PhDs (since 2016) at the Netherlands Institute of Sea Research and Wageningen University, and a number of specific research projects (https://www.pulsefishing.eu/research-agenda)
4	Electric fishing has been prohibited in Europe since 1998, alongside other destructive fishing methods "including the use of explosives, poisonous or stupefying substances", for the "conservation of fishery resources through [...] the protection of juveniles [...]".[1]	Fishing with electricity is prohibited. Based on scientific information that the innovation could improve the selectivity and reduce the fuel cost, the EU has allowed a number of fishers to test the technique (Haasnoot et al., 2016).
5	China, which used it in the 90s, banned it in 2000[2] because of its serious harmful effects for biodiversity.[3] Hong Kong had already banned it in 1999[4] because of its damaging consequences:[5] "Electric fishing harms or even kills most fish, including fish fry and other marine life. Such methods of fishing have a longterm deleterious effect on fisheries resources and the marine ecosystem".	[3: Yu et al. 2007] shows that electric fishing increased the efficiency and resulted in an overexploitation of the stock, which was the reason to ban the technique. Except for the effect on the target species that was related to the overfishing of the stock, the paper does not provide evidence for serious harmful effects for biodiversity. In the North Sea, the fishing effort, and hence the collateral damage to the ecosystem, is controlled by the TAC set for the target species (sole and plaice). The TAC also restricts the collateral damage of the fishery to the ecosystem
6	In Vietnam, "electric impulses and toxics to exploit aquatic resources is an act of exterminating the resources, damaging the ecology and polluting the habitat of aquatic resources",[6] and electric fishing was banned in 1996 [7]. Brazil, the United States and Uruguay have also banned electric fishing to "prevent habitat degradation" [8] The list of countries that have banned electric fishing is long, as seen below.	Not reviewed
7	Despite the proven destructiveness of electric fishing and against the advice of the Scientific, Technical and Economic Committee for Fisheries (STECF),[9] the European Commission and Council have authorized granting exemptions to use electric current in the southern part of the North Sea since late 2006.[10] In 2013, the 1998 Regulation was amended to include this principle of exemptions in the law (thus allowing Member States to equip up to 5% of their beam trawl fleets with electrodes), [11] but the Commission and Council have allowed further licences beyond the legal framework (see point 8).[12]	Bloom does not provide proof for the 'destructiveness' of pulse fishing. The serious concerns related to pulse fishing are being investigated at present. The ICES advice in 2006 (ICES, 2006b; ICES, 2006a)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. STECF concluded in 2006 (STECF, 2006) Although the development of this technology should not be halted, there are a number of issues

#	Bloom	Scientific evidence
		that need to be resolved before any derogation can be granted (p. 6). The EU nevertheless introduced a derogation (under Annex III (4) of Council Regulation (EC) No. 41/2006) and further licences were arranged under other parts of legislation (see #1) ICES observes (ICES, 2016) that 84 licences have now been issued to use pulse trawl in the Netherlands for scientific research and data collection purposes. This is well in excess of the 5% limit included in the original legislation. The increases in the number of licences issued were agreed at EU level in 2010 and 2014. ICES has no basis to conclude whether this level is appropriate or not, although it would seem over and above levels that would normally be associated with scientific research. ICES advises not to generalize from the results of the research carried out to date to allow expansion of the use of the pulse trawl outside the current area and fisheries allowed for in the current legislation. Conventional beam trawling has significant and well demonstrated negative ecosystem impacts. If properly understood and adequately controlled, electric pulse stimulation may offer a more ecologically benign alternative and could reduce fishing mortality on non-target species. However, it is unclear whether the current legislative framework is sufficient to avoid the deployment of systems that are potentially harmful for some marine ecosystem components (e.g. cod). While the systems currently used do not appear to have major negative impacts, ICES considers that the existing regulatory framework is not sufficient to prevent the introduction of potentially damaging systems.
8	The European Commission has thus caved in to lobbying from the Dutch fishing industry, whose trawl fleet has been teetering on the edge of bankruptcy since fuel prices rose in 2007 [13]. The economic model of the beam trawl fleet is extremely vulnerable, because of its structural dependency on fuel. Rather than questioning an inevitably doomed fishing method because of its unacceptable environmental impact and excessive fuel consumption, the Dutch have stubbornly pursued high-impact fishing methods rather than converting to more sustainable gears. → The Dutch fishing industry now wants electric 'pulse' fishing to be considered a 'conventional' fishing method so that it can be	The economic performance of the Dutch demersal fleet in 2006 had been negative for the 5th year in a row. The rising oil price, lower fish quota, lower value of quota as well as growing societal critique on the ecological effects of beam trawling, resulted in the foundation of the 'Task force sustainable north sea fisheries' in 2005. The task force wrote an advice for the Dutch government on how to deal with these threats to the sector (van Balsfoort et al., 2006). They advised (amongst others) a Fisheries Innovation Platform (VIP) to steer innovations as well as study groups to stimulate fishers to share knowledge and empower them to innovate towards more sustainable fisheries. The pulse has been one of the innovations which have

#	Bloom	Scientific evidence
	widely authorized without requiring special authorizations.	been taken up by the fleet, as well as a shift to twinrig and flyshoot fishing; improved cooperation within the sector; improved entrepreneurship in family businesses (in total 130 VIP projects were undertaken).
9	The electric current used, a 'pulsed bipolar current', is identical to that used by Tasers© (electroshock weapons) [14]. This type of current causes such violent, uncontrolled convulsions that 50 to 70% of large cods are left with a fractured spine and internal bleeding after the shock [15].	The 50 to 70% is not representative of the injuries in the pulse fisheries. [15] refers to a tank experiment where cod was exposed just next to the conductor at a maximum strength (worst case). A 2nd tank experiment showed a lower fracture rate (3/170 cod; Soetaert et al., 2016a). A 3rd tank experiment showed a spinal fracture in 1/26 cod (Soetaert et al., 2016b) The published evidence from samples collected on board pulse vessels indicates 9% injuries (4/45) in cod and 2% (1/57) in whiting (van Marlen et al., 2014).
10	Electricity can also weaken the immune system of worms and common shrimp, and increase their sensitivity to pathogens [16]. And this is just the tip of the iceberg, because we know nothing about the effect of the electric current on eggs, juvenile growth, fish reproduction, plankton or electro-sensitive species such as rays and sharks.	[16] could not find any adverse effects for lugworms, but found an indication of a negative effect on the immune system of shrimps. In a follow up experiment, however, exposing the shrimp 20 times instead of one, no effect on the immune system was found, indicating that this was most probably coincidence (Soetaert et al., 2016). Desender et al (2016) did an experiment with electro-sensitive catsharks showing that the food detection ability was not affected. Desender et al (2017) exposed eggs and larvae of cod to pulse stimulus. No adverse effects were found in 6 out of the 8 developmental stages studied. The eggs were exposed to a worst case exposure that only occur in a narrow zone next to the conductor. No effects were observed in a follow up experiment with sole eggs (Desender, 2018). A research project is currently conducted to develop the mechanistic understanding how electrical pulses may adversely affect marine life. Such a mechanistic basis is required to assess the effects on the wide diversity of life forms in the sea.
11	The research conducted so far by the Dutch has essentially focused on the economic performance of vessels, but electric 'pulse' fishing poses a systemic problem of unprecedented severity: its extreme efficacy inexorably empties the ocean. Small-scale and recreational fishers denounce a fishing method that turns European waters into a "graveyard" and a "garbage dump".[17]	In Belgium two PhD-projects were dedicated to the ecological effects of the flatfish pulse (Soetaert, 2015) and the shrimp pulse (Desender (2018). Research conducted by the Dutch on pulse fishing is reported in three peer reviewed publications and numerous reports (www.pulsefishing.eu). Peer reviewed publications studied the catch composition and selectivity (van Marlen et al., 2014), injuries in cod (de Haan et al., 2016) and discard survival (van der Reijden et al., 2017).

#	Bloom	Scientific evidence
		The concerns about the adverse effects of pulse fishing has shaped the Dutch research agenda which is focussed on the biological and ecological effects (https://www.pulsefishing.eu/research-agenda) The statement of fishers that the fishing grounds of pulse trawlers are a graveyard are most likely related to the accumulation of discarded fish on a local fishing ground which is being exploited for a period of days. This phenomenon is not specific for pulse trawls but will also occur in other fisheries which produce discards such as flatfish beam trawl, otter trawls targeting roundfish or nephrops (Uhlmann et al., 2014) and static gears (Depestele et al., 2014).
12	Electric 'pulse' fishing reduces the impact on habitats compared to 'regular' beam trawls, but still has harmful impacts on both habitats and marine life. Electric trawls are still bottom trawls: they are dragged along the bottom and impact marine habitats. In fact, it is reported that the electrodes still penetrate into the sediment and that the trawl shoe goes six centimeters down the sediment. See Baarseen et al. (2015)	The FP7-project BENTHIS has studied the mechanical impact (penetration depth, sediment resuspension, sediment mixing) of the tickler chain trawls and pulse trawls. The results show that the penetration of the pulse trawl in the sea bed is reduced. Penetration depth was estimated at 4.0 cm for the tickler chain trawl and 1.8 cm for the pulse trawl (Depestele et al., 2016; Depestele et al., in prep). Application of the newly developed trawling impact methodology, which was taken up by ICES in 2017 (ICES, 2017a), shows that the benthic impact of the pulse trawl vessels is reduced by 50% as compared to the impact using tickler chain beam trawls (Polet et al., 2018) Almost all beam trawl vessels have replaced the shoes plus beam by a foil, i.e. without trawl shoes.
13	Furthermore, electric 'pulse' trawlers are not selective at all. For 100kg of fish caught, 50–70kg are discarded (including plaice, dab and soles) (Cappell et al. 2016; Baarsseen et al., 2015) In comparison, sole netters discard only 6kg of fish per 100kg of fish caught (Kelleher, 2005)	The trawl fishery for sole has a high bycatch rate because of the use of a 80mm mesh size required to retain the slender sole. Since the catch efficiency of sole in the pulse trawl is increased relative to other species, the bycatch of the other species in the pulse trawl will be lower. Van Marlen et al (2014) reported a lower catch rate of undersized flatfish in the pulse, but this result has not been corroborated in further studies (ICES, 2017b). Although netters may have a lower bycatch of fish species, they may have other bycatch such as marine mammals such as harbour porpoises (Hall et al., 2000). Sole trammel netters along the Belgium coast were shown to have fish bycatch rates of 22% in weight (Depestele et al., 2012). Further, it is doubtful whether the sole TAC in the North Sea can be harvested by netters only.
14	Survival rates were measured for several	From research on survivability we know that:

#	Bloom	Scientific evidence
	discarded species and were very low, especially for undersized specimens: 15% for plaice, 29% for sole, and 16% for dab.(van der Reijden et al 2017)	survival rate of the bycatch in the commercial pulse fishery (plaice: 15%, sole 29%; van der Reijden et al., 2017) is higher than survival rates measured on board commercial (2 hr tows) beam trawlers in the 1970s and 1980s (plaice and sole <10%; van Beek et al., 1990). Uhlmann et al (2016) compared the reflexes of plaice and sole discards caught in the beam trawl and pulse trawl and showed that impairment of the reflexes was stronger in beam trawl discards than pulse trawl discards. Range of discard survival rates of other species as observed in 7 commercial trips is: Brill (0-35%), Turbot (18-62%), Thornback ray (40-81%) (Molenaar et in prep).
15	Since electric 'pulse' trawls are lighter than conventional trawls, they can operate in zones that were previously inaccessible, near the coasts. However, these areas are sometimes reproduction zones or nurseries for numerous marine species. Only low-impact, small-scale fisheries were operating there. This unfair and unreasonable competition is worrying, because it rings the death knell for small-scale fishing.	Pulse trawls can be used on softer grounds (Turenhout et al. 2016). Whether the impact on the marine environment is raised depends on the sensitivity of these habitats and its biota. This is part of the ongoing research impact assessment project.
16	Bled dry, French fishers are forced to redeploy their fishing effort in the Channel, so that they can continue their activities. They denounce an irresponsible fishing method with dangerous consequences for the whole ecosystem and the economic balance of the sector. UK fishers from Lowestoft are equally angry at the expansion of electric fishing. According to them, "going beyond 12 nautical miles is a waste of time. It's a graveyard". Same story in Belgium and the Netherlands: electric 'pulse' fishing threatens their very viability in the short term.	It is well known in fisheries science that different fishing gears may compete for the same fish (Rijnsdorp et al., 2008). As the catch rates are determined by the local densities, the introduction of a new and more efficient gear may adversely affect the catch opportunities of other gears (Sys et al., 2016). See reply #11 to statement of fishers that the fishing grounds of pulse trawlers are a graveyard
17	The current regulatory framework allows each Member State to equip a maximum of 5% of its beam trawl fleet. If the Netherlands were to comply with this legal limit, they would have 15 electric 'pulse' trawl licenses, not 84, as indicated by the European fleet register. According to Dutch researchers, there are now only 8 beam trawls fishing for sole without electricity in the Netherlands [24] → In October 2017, BLOOM filed a complaint to the European Commission against the Netherlands, for the illegal and unjustified allocation of exemptions. The Commission has not yet responded to this complaint.	See reply to #1 for the regulatory basis of the exemptions

#	Bloom	Scientific evidence
18	The massive increase in exemptions since 2012 is attributed first to experimentation [25], and second to the implementation of a "pilot project" [26]. Under the pretext of scientific research, a destructive fishing method is authorized against the recurrent advice of scientists. The European Commission is thus displaying complicity with a fishing practice that is as questionable as "scientific whaling". In 2015, the International Council for the Exploration of the Sea (ICES) acknowledged that "the issuing of 84 licences to carry out further scientific data collection is not in the spirit of the previous advice and that such a level of expansion is not justified from a scientific perspective. [...] This is well in excess of the 5% limit included in the current legislation. At this level this is essentially permitting a commercial fishery under the guise of scientific research" [27]. → In total, there were over 100 electric 'pulse' trawlers operating in Europe in 2017: 84 in the Netherlands, 12 in the United Kingdom, 10 in Germany and 2 in Belgium. Most vessels conducting electric 'pulse' trawling in Europe are under Dutch ownership.	See reply to #1 for the regulatory basis of the exemptions Concerning the number of vessels required for research the vessels of the original 5% would have been sufficient to study the immediate ecological impact of the pulse trawl on marine organisms and the benthic ecosystem. To study the impact at the scale of the fleet, the 84 licenses allow us to collect the relevant information on the distribution and catch rates required to estimate the impact on the North Sea without the need to extrapolate from a sample of the fleet.
	As things currently stand, it is impossible to check the electric parameters used on the vessels and the current sent into the bottom of the ocean. ICES considers that "the existing regulatory framework is not sufficient to prevent the introduction of potentially damaging systems" [28]. Moreover, several fraudulent behaviors have been reported aboard electric 'pulse' trawlers, for example the use of netting below the legal size [29] or illegal fishing in zones with seasonal closures [30]. It is not just ecosystems that are put under strain by electric fishing: the situation has become explosive between European professionals, and between fishers and the authorities. Following the discovery of an infraction, three inspectors were even dragged through the water in the nets of an electric 'pulse' trawler [31] (the crew members were accused of attempted murder) [32].	The pulse trawls are restricted to the following maximum parameter values, in accordance with Regulation 850/1998, art 31 bis: - Power The maximum effective output power must not exceed 1kW per metre of beam length, measured between the connections of the electrodes and pulse modules. - Voltage (root mean square) The effective voltage between the electrodes is no more than 15 V - The vessel is equipped with an automatic computer management system which records the maximum power used per beam and the effective voltage between electrodes for at least the last 100 tows. It is not possible for non-authorised personnel to modify this automatic computer management system. The national and international fisheries inspection services control and enforce the fisheries legislation.

#	Bloom	Scientific evidence
19	Since August 2015 only, at least 5.7 million euros of public subsidies have been allocated to the development of the industrial electric 'pulse' fishing fleet in the Netherlands, including 3.8 million euros of European funding (67% of the total).33 These public subsidies have been abusively granted for 'research', 'innovation' and 'better practices'. European Institutions and Member States need to stop using public funds for ecologically and socially harmful fishing practices. Public decision-making has to be consistent with the objectives of the Common Fisheries Policy and must show greater vision, courage and ambition for the future of European fisheries. → The Netherlands have not uploaded the file on public subsidies allocated from 2007 to 2015 under the "European Fisheries Fund" (EFF). For this reason, it is impossible to calculate the total amount of subsidies allocated to electric 'pulse' fishing since the introduction of the exemptions.	Only the 1[st] four vessels were subsidised to 40% of the investment in a pulse system with a maximum investment of €176,000 per vessel, in accordance with the European Commission in 2008 (Haasnoot et al., 2015). According to information from the ministry LNV, none of the other pulse vessels received subsidy to invest in the pulse gear. 3,8 mln. Dutch EMFF budget has been committed to two research projects about pulse fisheries. One project is an impact assessment about pulse fisheries. This study will form a coherent project that aims to develop the fundamental knowledge on the effects of electricity on marine organism and the benthic ecosystem required to assess the ecological consequences of this new fishing method. Another project aims to study the selectivity gain that pulse technology can have in the shrimp fishing industry. The main value of pulse technology in the shrimp fishing industry is to reduce by-catches. In compliance with Commission Regulation (EC) No 498/2007, the EFF subsidies were always electronically published with the CAP subsidies in a publicly available database. This database contained the grants for the EFF per calendar year (for CAP payments per financial year). These databases stayed online for 2 years. Furthermore all completed pilot-projects are published (and still available) on the website "Europa om de Hoek" (https://www.europaomdehoek.nl/projecten/?page=3&map=&radius=&projectFund%5B0%5D=EVF&projectFund%5B1%5D=EVF).
20	A fishing method in total contradiction with our international commitments... As part of the Sustainable Development Goals adopted by the United Nations General Assembly in 2015, Europe committed to "end overfishing" and "destructive fishing practices" by 2020 (SDG 14.4).* The development and public funding of electric 'pulse' fishing is in total contradiction with these objectives ...and with our regulatory objectives. The basic regulations of the Common Fisheries Policy adopted in 2013** set an objective for the European Union to restore fish stocks and end overfishing by 2020 at the latest. The "Marine Strategy Framework Directive" (2008/56/ EC) demands the "conservation of the marine ecosystems. This approach should include protected areas and	The objective of the EU to restore fish stocks and end overfishing by 2020 have been met for North Sea sole and plaice, the two main target species of the pulse trawl fishery. The spawning-stock biomass (SSB) of sole has increased since 2007 and has been estimated at above the maximal sustainable yield (MSY) reference since 2012. Fishing mortality (F) has declined since 1997 and is slightly above F_{MSY} in 2016. The spawning-stock biomass (SSB) of plaice is well above the MSY reference, and has markedly increased in the past ten years. Since 2009, fishing mortality (F) has been estimated at around F_{MSY} (ICES, 2017e; ICES, 2017c) The scientific studies carried out so far do not support that pulse trawling is a destructive fishing practice (ICES, 2017b). The evidence support the conclusion that pulse fishing contributes to a

#	Bloom	Scientific evidence
	should address all human activities that have an impact on the marine environment". * United Nations (2015) Sustainable Development Goals — Goal 14: conserve and sustainably use the oceans, seas and marine resources. Available at: www. un.org/sustainabledevelopment/oceans. ** Regulation (EU) No 1380/2013.	substantial reduction in the adverse ecological and environmental impacts although a number of topics warrant further investigation (this report).
21	A destructive technological race. Electricity is also used to catch shrimp. Besides the Dutch, Belgian fishers have also shown some interest in this technique, but it uses a 'unipolar' (as opposed to 'bipolar' for flatfish) pulsed current. Although unipolar current is less harmful than bipolar current, such a technological race will also result in an increased fishing effort and thus aggravate the overexploitation of common shrimp.* The German Thünen Institute considers that electric fishing may be a viable alternative, but its position is solely based on i) reduced fuel consumption and ii) lower impact on habitats relative to beam trawling, as well as iii) potential decreased bycatch, but again only in comparison with one of the most high impact fishing gears there is: beam trawls. Therefore, similarly to research carried out by the Dutch IMARES Institute, effects on the whole marine ecosystem and ripple down effect on fishing communities are not accounted for.** * ICES (2014) Request from Germany and the Netherlands on the potential need for a management of brown shrimp (Crangon crangon) in the North Sea. ICES Advice 2014, Book 6 — North Sea — 6.2.3.4 — Special request, Advice October 2014. 10 p. ** See their public position at: www.thuenen.de/en/of/projects/fisheries-and-survey-technology/pulsetrawl-for-shrimp-fishery.	Research of the Belgian fisheries institute has shown the potential to reduce the substantial bycatch in the fishery for brown shrimp, including juveniles of commercial species such as plaice and sole (Polet et al., 2005; Verschueren et al., 2014) The PhD project of Desender (2018) has provided no support for concern about adverse effect of electrical stimulation on marine organisms. The traditional shrimp beam trawl is in no way comparable to a tickler chain beam trawl used in the fishery for sole and other flatfish. The gear deploys a light ground rope with rollers and is expected to have a substantial lower impact on the benthos (Eigaard et al., 2016).

[redacted]

3.9

Van: [redacted]@wur.nl>
Verzonden: dinsdag 27 november 2018 11:51
Aan: [redacted]
CC: [redacted]@ilvo.vlaanderen.be)'
Onderwerp: aanvraag toestemming garnalenpuls N2000 & onderzoeksplan
Bijlagen: Bijlage 2 Cranpuls visplan innovaties.docx; Aanvraag Toestemming Garnalenpuls_innovatiejr v271118.docx; Bijlage 1 deelnemende schepen.docx

[redacted]

In de bijlages vind je onze (concept)aanvraag voor de toestemming om in 2019 met de deelnemende schepen in N2000 gebied onderzoek te doen naar de garnalenpuls. Het jaar 2019 gaat om innovatie. In het onderzoeksplan (bijlage 2) worden de voorziene innovaties toegelicht en is een visplan per schip opgegeven.

Je hebt aangegeven graag mee te willen kijken naar het eerste concept voor 2019. Ik zie graag voor vrijdagochtend jouw opmerkingen tegemoet opdat wij de aanvraag op de deadline 30 november in orde kunnen maken. Zoals je ziet heb ik 2 footnotes moeten toevoegen omdat ik met ministerie nog 2 zaken moet afstemmen, over de einddatum van het project en de uitbreiding van het innovatie jaar. Ik ga er vanuit dat dat goed komt. Ik wilde echter wel genoemd hebben dat als het niet goed komt de begeleiding er anders uitziet en we niet een heel jaar kunnen volmaken met het project. Op vrijdag heb ik overleg met [redacted] van LNV, zij is vanaf nu het LNV aanspreekpunt voor dit project. Daarna wordt hopelijk ook meer duidelijk over deze twee zaken.

@[redacted], ter info stuur ik jou ook alvast de documenten toe. Kan jij aangeven wat jij voor de toestemmingen van RVO? Zullen wij daar anders later deze week even contact over hebben?

Groet,
[redacted]

><> Ik werk op maandag, donderdag en vrijdag <><
><> My workdays are Monday, Thursday and Friday <><

From: [redacted]
Sent: dinsdag, november 13, 2018 8:57
To: [redacted]
Subject: RE: DOMUS-18288359-v1-Wet_natuurbescherming;_onderzoeksmatige_pulsvisserij;_aangepaste_tuigconfiguratie_[redacted]

Hallo [redacted]

Ik zal een week extra meenemen in de instemming. En ja; ik kijk zeker graag alvast mee in een eerste concept voor 2019!

Groet,
[redacted]