[redacted]

Van: [redacted]@vissersbond.nl>
Verzonden: maandag 10 oktober 2016 10:48
Aan: [redacted]
Onderwerp: FW: Agenda overleg WG pulsonderzoek - 17 oktober - IJmuiden
Bijlagen: Agenda puls WG onderzoek 17 10 2016 IJmuiden.doc; Onderzoeksprogramma pulsvisserij platvis 2016 - 2019.pdf

Hoi [redacted]

Er ging iets mis met het versturen van de agenda naar jou en naar [redacted]. Ik stuur hem hierbij opnieuw en even zonder de bijlagen over de bijeenkomst van het Interantional Advisory Committee (die heeft [redacted] voor je). Misschien dat dat beter gaat.

Groeten,

[redacted]

Van: [redacted]
Verzonden: maandag 10 oktober 2016 10:34
Aan: [redacted]@noordzee.nl'; [redacted]; '[redacted]@minez.nl'; [redacted]@visned.nl'; [redacted]@visned.nl'; [redacted]@wur.nl'; [redacted] | VisNed.nl'; [redacted]@elasmobranch.nl'
CC: [redacted] '[redacted]@visned.nl'
Onderwerp: Agenda overleg WG pulsonderzoek - 17 oktober - IJmuiden

Beste leden van de werkgroep onderzoek puls,

Graag wil ik hierbij bevestigen dat het overleg van de werkgroep onderzoek puls zal plaatsvinden op 17 oktober vanaf 10:00 bij Wageningen Marine Research in IJmuiden (Haringkade 1).

In de bijlage kunnen jullie de agenda vinden. Als daarover vragen zijn of als jullie toevoegingen hebben hoor ik dat graag.

Ook stuur ik jullie:

- Het verslag van de eerste bijeenkomst van het International Advisory Committee (ISAC) on Pulse Fisheries en de bijbehorende bijlagen.
- Het onderzoeksplan Pulse Trawl Impact Assessment 2016 – 2019.

Met vriendelijke groet,

[redacted]
Projecten

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Bezoek onze stand (D19 + D20) op 7 en 8 oktober 2016 tijdens HFE 2016 URK

Nederlandse Vissersbond

VisNed
VISSERS MET TOEKOMST

2.147a

Agenda werkgroep onderzoek pulsvisserij

Datum: maandag 17 oktober 2016
Tijd: 10:00 tot 13:00 uur
Locatie: Wageningen Marine Research, Haringkade 1 IJmuiden
Voorzitter: [redacted]
Secretaris: [redacted]

1. Opening

2. Vaststellen agenda

3. Mededelingen en ingekomen stukken

   a. Terugkoppeling EZ eerste bijeenkomst International Advisory Committee (ISAC) on Pulse Fisheries (zie bijlage)

4. Taakopvatting werkgroep onderzoek pulsvisserij

5. Onderzoek platvispuls (stand van zaken)

   a. Pulse Trawl Impact Assessment 2016 – 2019 (zie bijlage)
   b. Beleidsondersteunend pulsonderzoek
   c. Vangstgegevens platviskotters (2010-2015), onderzoek gerelateerd aan pulstoestemming

6. Onderzoek garnalenpuls

7. Wat verder ter tafel komt / rondvraag

1 Project scheme

1.1 Problem definition

The North Sea flatfish fishery is mainly carried out with vessels that tow double beam trawls over the sea bed to target sole and plaice (Rijnsdorp et al., 2008). This beam trawl fishery, in particular the one targetting sole, is characterised by a substantial bycatch of undersized fish, benthic invertebrates and debris. In addition, beam trawls have an adverse impact on the structure of sea bed habitats and impose an additional mortality on invertebrate animals in the path of the trawl (Lindeboom and de Groot, 1998; Kaiser et al., 2006). In terms of benthic impacts, flatfish beam trawls together with shellfish dredges are considered to be the most detrimental fishing gears in the North Sea (Polet and Depestele, 2010). These benthic impacts are related to tickler chains that are used to chase sole out of the sea bed. These tickler chains dig into the sea bed to a depth of 8cm or more (Paschen et al 2000).

Research into alternative methods to catch sole has been conducted since the 1970s to increase the selectivity for sole. This research focussed on the use of electrical pulses that led to a contraction of the body muscles (cramp response) during exposure which prevented the sole to dig into the sediment. The U-shaped form of a cramped sole makes it easier to catch in a bottom trawl. After successful commercial trials since 2005, an increasing number of vessels has switched from the traditional tickler chain beam trawls to pulse trawls. These vessels operate under a temporary licence, because use of electricity in catching marine fish is not allowed in EU waters (EC nr 850/98, article 31: non-conventional fishery techniques).

The introduction of pulse fishing in the North Sea has raised serious concerns among stakeholders (fishing industry, NGO's) and EU member states. Kraan et al. (2015) made an inventory of the concerns which were discussed at a pulse dialogue meeting organised in July 2015. The concerns are related to the lack of knowledge about the ecological effects of electrical pulses on the marine ecosystem and the risk of an increase in catch efficiency and the consequences for other fisheries. The concerns were aggravated by the increasing number of temporary licences to 84 in 2014, as part of a Dutch pilot project in preparation of the introduction of the landing obligation under the reformed European Common Fisheries Policy.

The question whether pulse trawling can be accepted as a commercial fishing method in the EU will be evaluated in the near future. In order to support the decision making process on permanent acceptance of the pulse trawl technique, scientific information is required on the effects of electricity on marine organisms and the benthic ecosystem, and implications of a transition of the beam trawl fleet. The Pulsetrawl Impact Assessment (IAPF) project developed below aims to provide the scientific basis for the assessment of the consequences of a transition in the flatfish fishery from using traditional tickler chain beam trawls to the pulse trawl.

1.2 Background

The electrical field generated by flatfish pulse gears is heterogeneous. Highest field strengths occur in close range of the conductor and dissipates at increasing distance from the conductor (de Haan et al., submitted). No information is available about the penetration depth and dependence on sediment characteristics of the electrical fields in the seabed.

Laboratory experiments have been conducted to study the probability that cod develops vertebral fractures over a range of pulse characteristics. Field strength and frequency were shown to have significant effects. Fractures were observed in marketable cod where the probability of injuries decreased with body size. No fractures were observed in small cod that can escape through the meshes (de Haan et al., submitted). In other experiments, using similar exposure strength, no fractures were observed (Soetaert et al., submitted). This suggest that the body condition of the cod may influence the sensitivity for injuries (Soetaert, 2015). Analysis of a number of cod and whiting sampled from the catch of pulse trawl vessels showed that around 10% of the marketable sized cod and about 2% of the whiting (discard and marketable sized) (van Marlen, 2014; Rost, 2015). In a laboratory experiment in which dab were exposed to pulse stimulus, no injuries or any other deformity were detected (de Haan et al., 2015).

Marieke Desender and Maarten Soetaert (University Ghent), in collaboration with Hans Polet and Bart Verschuren of ILVO (Oostende), carried out a number of experiments to study the effects of the flatfish and the shrimp pulse trawl on a variety of fish species and benthic invertebrates (Soetaert, 2015; Desender and Soetaert, pers comm). These studies showed that species respond to the electrical stimulus. The response is species specific and is related to the strength of the stimulus. The experimental studies did not detect injuries in the species under study. No effect was detected on egg, larval and juvenile stages of cod, except for the first feeding stage. In dogfish that were trained to locate artificial prey buried in the sea bed with their electro-sense organs, no effect on the success rate of prey detection was observed after exposure to the pulse stimulus.

In conclusion, the available evidence shows that marine organisms respond to electrical stimulation and that in some species electrical stimulation may lead to fractures and haemorrhages. In order to evaluate the consequences of electrical stimulation in the marine ecosystem, a framework is missing that can explain its effects on the organisms and which can be used to make predictions that can be compared with empirical observations. No information is available on the strength of the pulse stimulation in the trawl path (water and sediment).

1.3 Aim of the project

The overall aim of this project is to assess the longterm impact of the commercial application of pulse trawls in the North Sea flatfish fishery. In order to fulfill the overall aim, predictive models of the effect of electric pulses on organisms and on different ecosystem components will be developed and applied. The results will be integrated to assess the consequences of a transition in the flatfish fishery from using tickler chain beam trawls to pulse trawls on the bycatch of undersized fish (discards) and the adverse impact on the North Sea ecosystem.

These aims lead to the following research questions:

1. Marine organisms: what is the response of selected marine organisms representing different groups of fish and invertebrate species (such as roundfish, flatfish, rays and sharks, bivalves, crustaceans, polychaetes) to the exposure by a range of pulse parameters representative for the commercial pulse trawls?
2. Benthic ecosystem: what is the effect of pulse trawling on the functioning and biogeochemistry of benthic ecosystems (short-term and long-term effects)?
3. Sea bed: what is the effect of pulse trawling on the fish stocks and the benthic ecosystem at the scale of the North Sea? Does a transition in the flatfish fishery from conventional beam trawling to pulse trawling contribute to a reduction in bycatch and adverse impact on the benthic ecosystem?
4. Synthesis: what is the effect of the transition of the tickler chain beam trawl fleet to a pulse trawl fleet on the bycatch of undersized fish and on the adverse effects on the benthic ecosystem?

1.4 Approach

The research project comprises of four inter-related work packages and use a variety of complementary approaches. In addition to these four workpackages dedicated to the research, a fifth workpackage dedicated to project coordination and management will be included.

WP 1: Marine organisms.

WP 2: Benthic ecosystem.

WP 3: Sea bed (scaling up to the North Sea level).

WP 4: Impact assessment (synthesis).

The individual work packages are described in section 2 of this tender document. Here we give a summary of each WP and describe how the WPs are inter-related.

WP1 will carry out *laboratory experiments* and develop *predictive models*. Models will be developed of (i) the electrical fields generated by pulse trawls under different environmental conditions and (ii) the electrical fields inside marine organisms. Laboratory experiments will be conducted on the effect of electrical pulses on the behaviour and mortality of a selection of marine organisms. To cope with the diversity in species that will be exposed to pulse trawl fishing in the North Sea, species will be classified according to their building plan that determines their sensitivity to electrical stimulus. Fish samples of the various groups will be collected on board of pulse trawlers and analysed for injuries. Collected data will be compared to modelling results to optimize and fine-tune the boundary conditions and to estimate confidence intervals for model simulations.

WP2 will carry out *field and laboratory experiments* on the effect of electric pulses on the functioning of benthic ecosystems, and develop *predictive models* how ecosystem functioning is affected by pulse trawling. Field samples of the sea bed will be taken from stations before and after pulse trawling. The species composition and functional characteristics will be determined, and the samples will be exposed to electrical stimulation or mechanical disturbance to measure the effect on geochemical fluxes.

WP3 will develop the tools to integrate the results of WP1 and WP2 in a *spatialy explicit predictive model* of the distribution of fishing activities of pulse trawl fishers and its consequences for the catch, bycatch, and species that are not retained but come into contact with the electric field as well as the impact on the benthic ecosystem.

In WP4 the results obtained in WP1 – WP3 will be synthesised in an Impact Assessment that will quantify the consequences of a transition of the flatfish fleet from tickler chain beam trawls to pulse trawls. Consequences will be assessed in terms of the bycatch and the impact on the benthic ecosystem (fish and bentic invertebrates). In order to be able to respond to the topics raised in the stakeholder interactions the integration will be organised in a flexible manner.

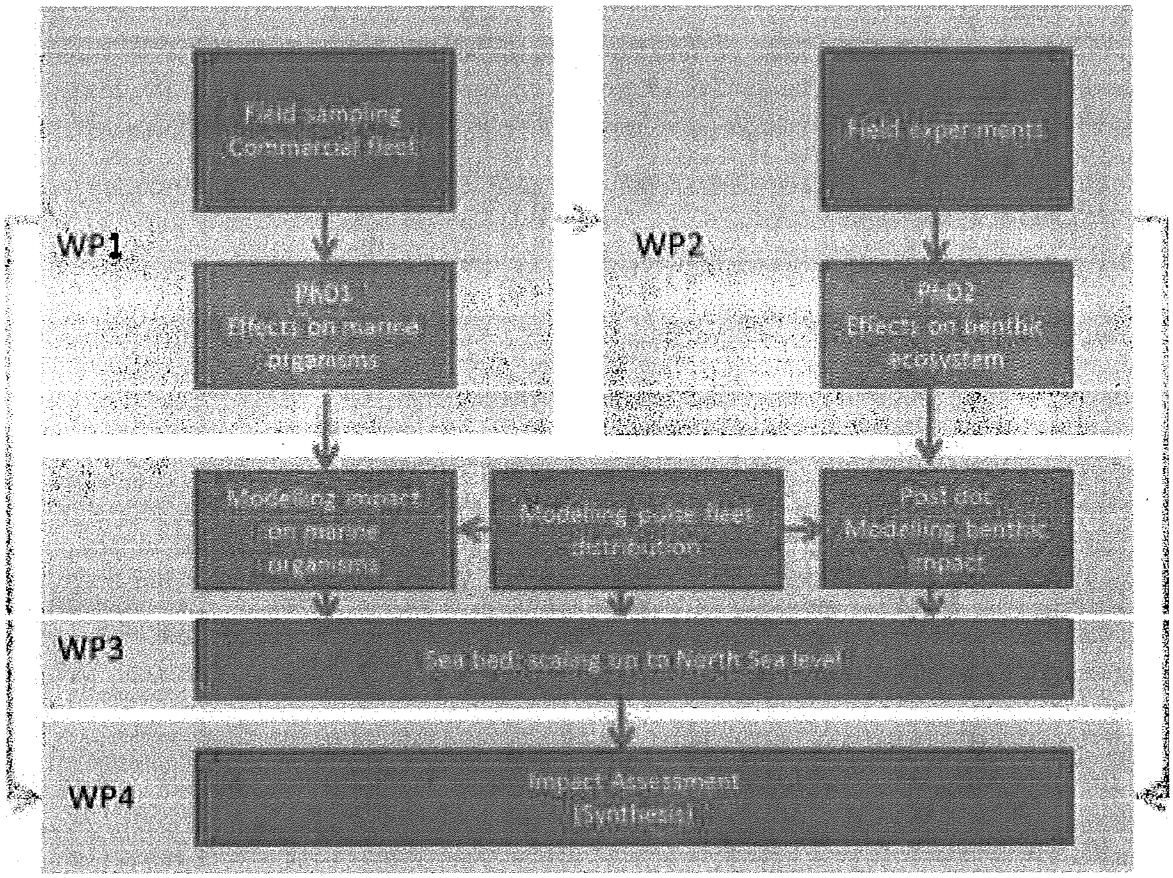

Figure 1. Relationship and flow of information between the work packages

1.5 Results of the project

WP1 The effect of electricity on marine organisms

WP1 will show how and why fish and benthic invertebrates respond to electrical stimuli and show the critical levels at which adverse effects will occur. This knowledge will be synthesized in a model. The model predictions will be compared to the injuries observed in different types of fish and different fish sizes in the catch of commercial pulse trawlers. As the work is primarily focused on controlled experiments, the strength of the scientific evidence obtained will be high. The mechanistic knowledge obtained will be summarised in a predictive model that can be used in WP3.

WP2 The effect of electricity on the benthic ecosystem

WP2 will show how benthic ecosystem functions are affected by the exposure to electrical pulses. As the work is primarily focused on controlled experiments, the strength of the scientific evidence obtained will be high. The field study where benthic samples are being taken from sites before and after experimental trawling will likely provide strong evidence, although the statistical power of these field experiments is generally lower than in the laboratory experiments. The mechanistic knowledge obtained will be summarised in a predictive model that can be used in WP3.

WP3 Sea bed (scaling up to the North Sea level)

WP3 will develop a predictive model of the distribution of pulse trawl effort in relation to benthic habitats on the scale of the North Sea. To estimate the effect of pulse trawling on the catch and bycatch of target and non-target species on the scale of the fleet and of the North Sea, the model will be coupled to the models and results of WP1 and WP2 which predict the effect of electrical pulses on species and ecosystem functions. If feasible, WP3 will respond in a flexible manner to possible changes in the societal debate around the pulse trawl.

WP 4 Impact assessment

WP 4 will synthesise the results of WP 1, 2 and 3 to provide an impact assessment of the effects of the transition of flatfish fishery from tickler chain beam trawls to pulse trawl gear on the bycatch and impacts on marine organisms and the benthic ecosystem.

The results arising from workpackages 1, 2 and 3 will be reported in manuscripts for scientific journal articles. The results of workpackage 4, the impact assessment, synthesis and executive summary of the results of workpackages 1, 2 and 3, will be communicated in a report (English). The executive summary will also be made available in Dutch.

All deliverables are described in section 2 of this tender document.

1.6 Boundaries

WP1 and WP2 are focussed on developing the fundamental scientific knowledge about the effects of electricity on marine organisms and on the benthic ecosystem by employing a PhD or postdoc. WP3 is focused on the application of this fundamental knowledge in a framework to quantify the effect of commercial pulse trawl fishing and estimate the impact at the level of the total fishing fleet at the scale of the North Sea.

WP1 will generate a predictive model for the effects of electrical pulses on marine species. Experimental data will be gathered to estimate the most important and critical parameters in the model. Experiments are, however, constrained by the available time and budget. Inevitably, additional parameters will have to be taken from available literature, and may thus depend on required generalizations. Model simulations will therefore provide best estimates of effects rather than hard thresholds for damage.

IAPF will carry out the experiments on a selected number of species and a few sea bed habitat types. Criteria to select the species is that they represent groups which differ in their susceptibility for electrical stimulation, occur on the fishing grounds of the North Sea flatfish fishery, are easy to maintain in the laboratory, and can be collected in sufficient numbers. Whether the species is charismatic is not a criterion for being selected. Field studies are planned in representative habitats of the fishing grounds of the North Sea flatfish fishery.

Long-term effects of pulse stimulation will be estimated using ecosystem models that are parameterised with the results of the short term effects measured in this project. The available budget does not allow a long-term effects study of pulse trawling *in situ*.

If new concerns are raised during the stakeholder consultations during the course of the project, we will attempt to include these concerns in the research project but cannot warrant that all questions raised can be dealt with.

1.7 Applicability

The results of IAPF will provide a scientific basis for the understanding of the effects of electrical pulses on marine organisms and benthic ecosystems. This fundamental scientific knowledge will be used to assess the effects of the transition in flatfish fisheries from using tickler chain and chainmat gears to pulse trawls. The effects will be expressed in the proportion of injured fish, benthic ecosystem functioning and the bycatch of undersized fish and benthic invertebrates. The impact of the pulse trawl fleet will be compared with the impact of the fleet if the vessels would use the traditional beam trawl gear. The results will provide essential input for evaluation by the European Union of the acceptability of the pulse trawl technique as a fishing method in the North Sea.

1.8 Preconditions

The consortium will only implement the proposed research program when the activities comply with relevant legal frameworks. Relevant legal frameworks include regulations under the Common Fisheries Policy, the "Visserijwet" in relation to experimental puls trawling and the "Wet op de dierproeven" in relation to the animal experiments foreseen in this project.

The consortium is responsible for timely application for the permits required for legal implementation of the research program. However, actual granting of permits is beyond the control of the consortium. The consortium can only implement the proposed research program when all required permits are granted.

In WP2, study plots will be trawled at a prescribed intensity by a commercial pulse trawler to study the effects of pulse stimulation and mechanical disturbance on the benthic ecosystem functioning. Fishing vessels will be selected in collaboration with the fishing industry organisations and supported by scientific quota by the Ministry of Economic Affairs (EZ).

The quality of the Impact Assessment carried out in WP4 will depend on the information available on the pulse settings of the pulse fleet. This information will be provided by the Ministry of EZ and the fisheries organisations (VISNED, Nederlandse Vissersbond).

To allow for cost efficient use of vessel time, Campaign 1 of WP2 will be carried out in combination with the Beam Trawl Survey (BTS) on board of the Tridens. The Ministry of EZ will provide the research vessel Tridens under the framework contract between the Ministry and Rijksrederij as all vessel time for the Ministry is covered under this contract in an efficient way. Should combining with the annual beam-trawl survey BTS not be feasible, vesseltime (any suitable vessel) will be requested through the Ministry under the same framework to allow for cost-efficient use of vessels. Additional costs will be covered through this proposal.

In consultation with the client, the duration of the project will be adjusted to allow the PhD candidates to finish their 4-year contract within the scope of the project. In case no suitable PhD candidate can be employed within a reasonable time, a post doc will be hired. PhD candidates have to complete a training and supervision plan (TSP) of about 35 ECTS as part of their PhD training.

For the information on the catch composition of pulse trawlers, the project relies on the data collected at the routine discard sampling carried out by IMARES, and the self sampling program by a selection of pulse trawlers according the agreed protocol.

2 Workpackages

2.1 Workpackage 1: Modelling the effects of pulse stimulation on marine fish and invertebrates

2.1.1 Summary

Pulse fishing has several advantages over traditional tickler chain beam trawls, including reduced bycatch and greatly reduced fuel consumption. It also raises concerns due to potentially much wider side-effects on a variety of ecologically relevant species. In this project we will develop a general framework for predicting effects of pulse stimulation on a variety of species in marine ecosystems. The model will include calculations for the spatial and temporal structure of electric fields for variable settings of electrical stimulation parameters, and for arbitrarily defined target areas.

Differential effects of these electrical fields on different groups of organisms (both invertebrates and fishes) will be quantified. Hereto, we will 1) quantify effects of body shape, size and tissue composition on internal current flow, and 2) link current flow to behavioural, kinematic and morphological effects. Several sets of laboratory experiments will be conducted to provide the data for these steps, and to fine-tune the model.

The result is a model framework that will allow to asses optimal pulse parameters for species and size specificity, within the constraints of an acceptable level of collateral damage in pulse fishing.

2.1.2 Background

The effects of electrical pulses on marine organisms have previously been studied in a number of species. Typically these studies quantified effects of field strength on a particular species of interest. A main concern, however, is that electrical fishing potentially also affects all other organisms in the neighbourhood. Despite a relatively small volume of bycatch, this may lead to severe long-lasting damage to the ecosystem. The general aim in electrical fishing therefore should be to optimize probability of catching a particular species, while minimally affecting other species. Preferably, the method should also enable size selectivity within the species of interest.

To what extent these goals can be achieved depends on differential susceptibility of a species relative to its biotic (and a-biotic) environment. In order to gain insight in the effects of pulse fishing on species interacting in a complete ecosystem it is therefore imperative to predict susceptibility of all relevant species to electrical fields. Obviously, this is a complex problem. Effects of electrical current vary both with environmental conditions, with the type of electrical field employed (both spatial and temporal modulations), and with the type of organism. In this project we aim to develop the required insight and tools to predict effects of electric pulse fishing on relevant organisms in an ecosystem.

We propose to develop a general model describing the effects of electrical fields on populations of different animals. To achieve this we will study and quantify the most important factors determining effects of electrical pulses on individuals of different species. Wherever possible we will use data from literature to extract quantitative relationships. In addition we will conduct the required experiments on a range of species so as to allow generalizations to different fish and invertebrates. Once we have a general description of electrical effects as a function of species, animal size, and animal shape we will be able to simulate fishing trials with different electrical field settings and distributions of animals within the ecosystem so as to determine the settings that provide optimal yield with minimal collateral damage.

Effects of electrical pulses vary with the properties of the stimulus and with properties of the organism and their environment. In order to develop a model that can be used to quantify stimulus effects and to investigate optimal (and acceptable) stimulus settings, the main factors influencing an organisms' sensitivity to electrical stimulation need to be quantified. These factors include for example size and shape parameters, spatial orientation and conductivity of body parts. In addition, the specific structure of the neuronal and motor system will play a critical role. The latter includes for example the type of skeleton: similar internal gradients of electrical potential may result in widely varying effects for organisms with a vertebral column and axial musculature versus invertebrates with an exoskeleton or a hydrostatic skeleton in combination with giant axons in superficial nerve cords. In this project we will set up the general framework for simulations of electric fishing trials, and we will investigate to what extent differences between organisms need to be taken into account.

2.1.3 Objectives

To develop a general quantitative framework for predicting effects of pulse stimulation for different groups of animals, including flatfish, roundfish, elasmobranchs and different groups of invertebrates.

2.1.4 Research tasks

- Develop a quantitative model of the spatio-temporal structure of electric fields for variable pulse-stimulus settings.
- Develop a model for predicting current flow in animals subjected to external electrical fields.
- Link internal current flow to behavioural, kinematic and damaging effects.
- Use the complete model to study effects of pulse parameters on flatfish yield and size specificity as well as the amount of bycatch and additional damage to the fauna in general.

2.1.5 Workplan

Task 1.1 A quantitative model of the spatio-temporal structure of electrical fields

The general framework will consist of two main components. Part 1 consists of calculating the spatio-temporal structure of the electrical field based on variable stimulus settings. The model will specify the full three-dimensional field, to allow for analysing effects in the water column, at the sediment-water interface and within the sediment. Part 2 of the general framework consists of calculating the spatio-temporal variation in electrical currents within organisms in response to the electrical field. For part 1 parameters of interest are, among others, the spatial distribution of electrodes, strength of pulses, the temporal structure of pulses (AC/DC/pulsed DC etc.), and the speed and path at which the stimulus traverses a targeted area. The model will also include the interactions of stimulus parameters and the properties and spatial layout of the target area (distance to sea floor, composition of the sea floor), enabling the investigation of different stimulus locations on target species at different positions in the water column or sediment. Previous research has shown large, species-specific effects of stimulus type, strength and duration. The model should therefore enable us to investigate how such stimulus variations affect a wide range of target species. For a first approximation we will calculate the field strengths without interactions from the organisms present in the field, using existing commercially available finite element models.

Task 1.2 Modelling the internal current flow

In order to link externally applied electrical fields to behavioural and physiological effects we will need to model internal electrical parameters for different groups of animals. Internal current flow is the main determinant for physiological effects and greatly varies with general morphology, body plan and orientation in the field. To predict species-specific effects one therefore needs to quantify the spatiotemporal pattern of current flow within organisms. This part of the model takes into account basic knowledge of body architecture for different groups of fish and invertebrates.

Task 1.3 Experiments linking internal current flow to behavioural, physiological and damaging effects.

Much research in this field has been done for fish and many of the required parameters linking current flow to physiological effects, including damage and stunning effects can be obtained from literature and from previous experiments by collaborators at ILVO (Hans Polet) and IMARES. Some fundamental questions, however, remain unanswered so far. Little information is available on damage by electrical pulsing for marine invertebrates. Due to, for example, the presence of ventral, superficial nervous systems with giant motor nerves these species may be specifically susceptible to electrical fields. Moreover, disturbance of the invertebrate part of the ecosystem may have severe effects on energy flow in an ecosystem and might therefore have harmful delayed effects. This knowledge gap will be filled by conducting susceptibility experiments on invertebrates, in collaboration with Hans Polet at ILVO and in collaboration with IMARES and NIOZ at Yerseke. Invertebrates will include specimens of the main fyla: crustaceans, annelids, bivalves and echinoderms, for which we will quantify responses for a range of stimulus parameters.

Little information is also available on the diversity of behavioural effects for small amplitude stimuli that are too weak to paralyze but sufficient for detection and evoking an escape response. Measuring behavioural responses to a set of (approaching) potential stimuli will allow us to estimate the fraction of individuals that will be subjected to large-amplitude (nearby) stimuli. In a first set of experiments we will therefore quantify fleeing behaviour in widely different organisms to low amplitude stimuli. Escape response predictions, in combination with spatio-temporal dynamics of stimulation will allow for a highly improved estimate of the number of organisms subjected to potentially damaging high amplitude stimuli.

A third question that we will specifically address experimentally concerns effects of electrical pulses on behavioural swimming responses of elasmobranchs. For a range of amplitudes of the electrical pulse the responses will be monitored. This information will be used in the final model to predict the effects of pulsetrawl fishing on bycatch and damage in elasmobranchs.

Task 1.4 Effect of fish size on the incidence of vertebral fractures across fish species

Previous studies have reported vertebral fractures of cod and whiting caught in commercial pulse trawls. In order to investigate the magnitude of this phenomenon, we will quantify the damage using digital X-ray photography in relation to fish size and species group (cod, whiting, roundfish, flatfish). Fish samples will be collected on board of commercial pulse trawlers by IMARES to warrant representative sampling. After screening a range a fish species of different building plans, the effect of size and season will be investigated for a selection of species showing highest incidence rates. Collected data will be compared to modelling results to optimize and fine-tune the boundary conditions and to estimate confidence intervals for model simulations.

Task 1.5 Numerical simulations of pulse fishing trials

The experimental results will be used to fine-tune the modelled effects of electrical stimuli in natural settings on different types of organisms. The model framework will then allow us to study effects of electrical stimulation on the total catch of the pulse trawl fleet, and more importantly, to study parameters of stimulation (spatio-temporal current profiles) that minimize collateral damage in pulse fishing. The outcome of the simulations will be compared to actual bycatches and their damage in pulse fishing trials (part 4).

2.1.6 *Time line*

		2016				2017				2018				2019			
	Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
WP1	1.1																
	1.2																
	1.3																
	1.4																
	1.5																

2.1.7 *Deliverables*

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 a diverse group of animals (WU). Fine tuning of the model frame work depends on data gathered in experiments that will be done in cooperation with ILVO and IMARES.
3. Report on susceptibility of marine invertebrates to electrical pulses.
4. Report on behavioural responses in different groups of fish to low amplitude electrical pulses.
5. Report on effects of electrical pulses on behaviour in elasmobranchs (WU & IMARES).
6. A model framework for numerical simulations of pulse fishing effects; specificity of catches, bycatches and collateral damage.
7. Report on damaging effects in roundfish bycatch by electrical fishing on the basis of Xray photographs. Combined effort of IMARES (field samples) and WU (X-ray analysis)

2.1.8 *Role and responsibility of partners*

WU will act as WP1 leader. As WP leader, WU is in charge of and responsible for monitoring and supervising the proper execution of the WP with respect to work program and deliverables. IMARES (de Haan) will provide advice on the experimental set up of the electrical pulse system. IMARES will provide samples of a variety of fish species of different sizes and invertebrates sampled on board of pulse trawl vessels to be analysed for fractures by WU. Rijnsdorp (IMARES) as overall project coordinator will monitor and guide the work in relation to the links with the other WPs and in relation to the priorities formulated by the client.

WU is responsible for high through-put x-ray scanning of specimens from fishing trials, as provided by IMARES. WU is responsible for planning and executing the two sets of experiments, one in cooperation with ILVO, and one either performed at Yerseke or in Wageningen. Details of experiments at ILVO will be determined in cooperation with Hans Polet. WU will be responsible for execution of the experiments and providing the man power for experiments.

2.1.9 *Research team*

Name	**Position**	**Institution**	**Role & Responsibilities**
To be recruited	PhD or postdoc	WU	modelling, experiments
[redacted]	Senior scientist	WU	first supervisor
[redacted]	Senior scientist	WU	supervisor
[redacted]	Research assistant	WU	experimental setups

Name	Position	Institution	Role & Responsibilities
[redacted]	Senior scientist	ILVO	advisor/Collaboration experiments
[redacted]	Senior scientist	IMARES	global coordination/X-ray study collaboration
[redacted]	Researcher	IMARES	advisor

2.2 Workpackage 2. Differential effects of electrical pulse and conventional beam trawl fisheries on sediment biogeochemistry

2.2.1 Summary

To assess the effect of electrical pulse and beam trawl fisheries on sediment biogeochemical processes, we will perform three field sampling campaigns, looking at short to long-term effects. The thus obtained data, in combination with experimental data from task 1, will be used to calibrate and validate a mechanistic biogeochemical model that includes the effects of fisheries on sediment biogeochemical processes.

2.2.2 Background

Trawling effects on subtidal benthic communities range from destroying habitats (Reiss et al., 2009), induced mortality and lowered densities (Bergman and Santbrink, 2000), sediment resuspension with potential geochemical impacts (Pilskaln et al., 1998; Almroth et al., 2009) to long-term effects on benthic communities (Duineveld et al., 2007) or a reduction in biodiversity (Thrush and Dayton, 2002). To date it is rare to find studies that document fisheries effects on nutrient cycles. Via the remineralisation of organic matter sediments constitute important nutrient buffers, releasing and transforming nutrients and consuming oxygen. They thus influence pelagic productivity, and are the sites where excess inputs of nitrogen and phosphorus are removed from the marine environment. These ecosystem functions are potentially impacted by fishery activities.

Benthic animals play a central role in sediment nutrient cycles. Biodeposition by filter feeding animals (Kautsky and Evans, 1987), increases the input and burial of biogenic particles and thus augment the nutrient concentration in the sediment. Bioturbation by organism feeding and movement (Meysman et al., 2006) transports organic matter deeper into the sediment, affecting nitrogen and phosphorus removal, and also increases sedimentary nutrient concentrations. Flushing of animal burrows (bio-irrigation) increases the sediment-water exchange of nutrients and oxygen (Glud, 2008) with effects on sedimentary nutrient concentrations and biogeochemical process rates (Stief, 2013). Fisheries affect sediment biogeochemistry in several ways. There is a transient, short-term effect immediately after the fishing gear has perturbed the sediment. This manifests itself as mortality or exposure of surface-dwelling and superficially burrowing benthic organisms (Groenwold and Fonds, 2000), and instantaneous release of nutrients contained in the sediment, increasing benthic-pelagic nutrient exchange (Pilskaln et al., 1998). The transient disturbance of vertical sediment profiles may also stimulate microbial processes such as denitrification on very short time scales (e.g. Dahnke et al., 2012). On the long term, following the disturbance, the system will gradually evolve towards an equilibrium that may or may not differ in biogeochemical characteristics with respect to the initial state.

In this PhD project we will investigate the differential effect of beam trawl and electrical pulse fisheries on sediment nutrient cycles using a combined field and modelling approach. Our working hypothesis is that pulse and beam trawl fishing differentially affect survival or activity of specific macro- and megafaunal animals on the one hand and the integrity of the upper sediment on the other hand, with repercussions on the system's biogeochemistry. In the short-term, fishing may boost benthic-pelagic coupling while long-term effects may either increase or decrease it (e.g. Van Denderen et al., 2013).

2.2.3 Objectives

- Assess the effect of electrical pulse trawl and beam trawl fishing on benthic ecosystem functioning, in particular on sediment biogeochemistry (short-term and long-term effects).
- Develop a predictive mechanistic model of the impact of beam trawl and electrical pulse fisheries on benthic-pelagic coupling.

2.2.4 Research tasks

- Perform *ship-board* experiments to assess short-term effects of pulse and beam trawling on biogeochemistry.
- Perform *in situ* measurements to quantify short-term effects of pulse and beam trawling on the benthic ecosystem.
- Perform field biogeochemical rate measurements in areas with different fishing intensity to assess long-term fisheries effects.
- Develop a mechanistic diagenetic model representing the key ecosystem functions (bio-irrigation, bioturbation, sediment-water exchange rates of oxygen and nutrients) and how they are impacted by diverse fishing activities.

2.2.5 Workplan

We intend to perform three field campaigns, each comprising one week of ship time or longer, looking at fisheries effects on different time scales. The first two campaigns will visit the Oyster Grounds-Doggerbank area and make use of the Tridens (2016-2017) and the Pelagia (2017). The last campaign (2018) will visit the vlakte van de Raan, and make use of the Belgian ship, the Simon Stevin.

Task 2.1 Field campaign 1. Experimental assessment of the short-term effect of pulse stimulation on the sedimentary nutrient cycle.

Field campaign 1 will be split over two trips, in 2016 and 2017 and will be carried out onboard RV Tridens during the annual beam trawl survey (BTS). During these campaigns, sediment samples covering different sediment types at the Dogger Bank (2016) and the Oyster Grounds (2017) will be incubated *on board*. As the beam trawl survey is carried out during daylight hours, night time can be used to take the required samples. One week of the survey will allow enough samples to be collected for the areas in question. The large environmental heterogeneity in the North Sea necessitates a large sampling area that is sufficiently deep, so that the measurements represent average environmental conditions and that deep-burrowing animals are accounted for. We will therefore incubate relatively large cores, 6 in total, put in large tanks or cooling containers to buffer temperature. First these corers will be left undisturbed, and measurements in the overlying water performed. After 4 hours of incubations, they will be artificially perturbed such as to mimic the different fishing techniques in two ways, (1) by administrating electrical pulses and removing large epibenthic species, and (2) by mechanically disrupting the upper parts of the sediment and removing the epibenthic species.

- We will measure fluxes of various compounds that are involved in biogeochemical cycling (O_2, NO_3^-, NH_4^+, PO_4^{3-}, DIC). Bio-irrigation will be measured by adding bromide tracers. The concentrations of these substances in the overlying water will be measured at the start of the incubation and then at hourly intervals for at least four hours; the temporal change in their concentration is easily recalculated as sediment-water exchange fluxes.
- Two extra boxcores will be taken to sample for porewater profiles; subsamples will be used for determining grain size and porosity, and composition of solid substances (C, N, pigments). Bioturbation rates will be derived by modelling chlorophyll versus sediment depth profiles.
- After termination of an experiment, the box corers will be sieved and the major functional groups of sediment-inhabiting larger fauna will be enumerated, and weighed in the lab. The trophic position of the soft-bottom fauna will be analysed by their nitrogen (^{15}N) and carbon (^{13}C) stable isotopic composition. We will also sample bulk sediment and water column organic matter for stable isotopes.
- The last set of samples will be taken back to the lab, where the sediments will be further incubated for several days/weeks.
- To test whether electrical pulses have an effect on the release of toxic substances due to electrolysis, we will chemically analyze samples taken from the water column before, and immediately after administrating electrical pulses, and at the end of the pulse experiment.

Task 2.2 Field campaign 2. In situ effects of pulse and beam trawling on the benthic ecosystem.

In a second campaign we will revisit the Oyster Grounds with the RV Pelagia, follow the two types of fishing boats (electrical pulse and beam trawl) and perform *in situ* and on board measurements of sediments in their wake, and in an unfished area. The *in situ* measurements will position the two NIOZ landers where a fishing vessel has just passed and measure sediment oxygen uptake and take samples to determine nutrient fluxes over a period of 4 hours. We will inject bromide tracers to quantify *in situ* bio-irrigation rates. A NIOZ lander can hold three measurement units each of which comprises a small measurement chamber (i.d. 14.5 cm, 210 cm^2) thus sampling an area of about 2000 cm^2 with 3 units. Given the large variability of the sediments, such a small chamber may include or lack certain key species, and therefore we expect large variation in rates, and so replicate incubations will need to be done. In addition to these *in situ* measurements, on board incubations of entire box corers will be performed on sediments taken in the wake of fishing boats. We will perform the same type of analyses as during the previous campaigns.

Task 2.3 Field campaign 3. Long-term effects of fishing.

The two first campaigns will give detailed information of the impact of a single fishery event (manual perturbation in Task 2.1, *in situ* perturbation in Task 2.2) on the short time scale. We envisage a third campaign to look at acute as well as long-term effects of pulse fishing on biogeochemical cycling.

The sampling will be carried out in the Belgian Part of the North Sea, in cooperation with partner ILVO, using the Belgian vessel the Simon Stevin.

The campaign will be set-up as a Before-After-Control-Impact (BACI) experiment following the set-up described in Teal et al. 2014 and Depestele et al. 2015. The preferred sampling area is the closed area of the Vlakte van de Raan as this is within reachable distance for the Simon Stevin (docked in Oostende) and will be closed for fishing with tickler chains by 1 January 2016. The ultimate selection of the area will depend on required permits being granted. Within the sampling area seperate areas will be marked out of which one will serve as a reference area and the others will be fished according to different treatments: (1) low intensity, (2) high intensity, (3) pulse with electricity swiched off, allowing to desentangle mechanical versus electrical effects on the sediment. All areas wil be sampled during a T0 for a baseline and again during T1 following the fishing impact. The fishing treatements will be carried out by pulse fishermen on commercial vessels (agreed collaboration VisNed). Sampling will also be carried out within an area close to the BACI area where fishing has been recorded frequently (according to VMS data) over recent years. This will provide comparable measurements from an area of chronic effects of pulse trawling.

For each area of the BACI experiment as well as the area of chronic disturbance, we will perform sediment sampling for on board incubations as well as measuring for nutrients, particulate substances, and the soft-bottom benthic community according to the strategy described for the first campaign. To increase the predictive power of our research, we will also use rapid screening methods that measure proxies of the biological and biogeochemical sediment properties. The rapid screening will also be performed on the samples taken for detailed analysis, such as to relate both types of measurements.

- We will measure the total amount of nutrients stored in the sediments and their oxygen consuming capacity. Undisturbed sediments obtained with a small benthic corer (diameter 30 cm) will be subsampled and sliced in 0-5 and 5-10 cm layers. The slices will be covered with a specific volume of water of known nutrient and oxygen concentration. After shaking the sediment and homogenizing it with the overlying water, the nutrient and oxygen concentrations of the mixture will be assessed. The measurements will be repeated after incubating the cores in the dark and for one hour. Based on sediment porosity, and correcting for eventual desorption or adsorption, these data can be back-calculated for the nutrient load in the respective sediment sections, as well as the importance of oxygen-consuming substances that react at short time scales.
- We will use a sediment profile imaging camera (SPI) for rapid, in situ, imaging of biogeochemical layers in the upper part of the sediment (Birchenough and Parker, 2013). These cameras take a picture of the upper 20 cm of the sediment after a wedge-shaped prism has been slowly lowered in the sediment, and have previously been applied in trawl impact studies (Teal et al., 2014). The penetration depth of the wedge is indicative for the sediment compaction, while vertical coloration relates to the sediment redox potential and is indicative for the occurrence of sulfides (Teal et al., 2010). Images also show irrigated burrows as light spots, indicative for the presence of benthic irrigators.
- Multibeam measurements will be conducted across all areas in T0 and T1 to map the physical presence of trawl tracks in the sediment (following methods of Depestele et al. 2015). With the high precision multibeam onboard the Simon Steven, the depth of penetration of trawl tracks can be determined to cm resolution

Task 2.4 Development of mechanistic biogeochemical models

The field data will document porewater profiles and sediment-water exchange rates of oxygen and nutrients, bio-irrigation (using bromide tracers), and bioturbation (by fitting vertical solid tracer profiles). From these data we will estimate the total flux of degradable organic carbon deposited at the sediment surface, its degradation rate, transformation, and the burial of biogeochemical species using early diagenetic modeling (Soetaert et al., 1996). By interpreting pore-water profiles and flux estimates with these depth-resolved models, we will quantify the relative contribution of the denitrification and anaerobic mineralization pathways. Where vertical profiles are lacking but sediment-water exchange rates have been quantified, we will use mass balance models (Soetaert et al., 2000) to characterize the sediment biogeochemistry, as already applied to the North Sea by Braeckman et al. (2010).

2.2.6 *Time line*

	Task	2016				2017				2018				2019			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
WP2	2.1	■	■	■	■	■	■	■	■	■	■	■					
	2.2						■	■	■	■	■	■	■				
	2.3						■	■	■	■	■	■	■	■	■		
	2.4					■	■	■	■	■	■	■	■	■	■	■	■

2.2.7 *Deliverables*

1. Data set and manuscript on the short-term effects of sediment disturbances induced by electrical currents and mechanic stirring (experiments in campaign 1). We intend to run this campaign in summer 2016 and 2017 with the RV Tridens, where we will join the BTS campaign from IMARES; preparations will commence from the start of the project; lab analysis and sample processing will extend well into 2018.
2. Data set and manuscript on *in situ* effects of pulse and beam trawl fisheries (campaign 2). This campaign will be performed in 2017 with the RV Pelagia; data set will become available in 2018.
3. Data set and manuscript on long-term effects of fishing on sediment biogeochemistry in the Southern Part of the North Sea (campaign 3).
4. The process-based mathematical model. Quantification of the local effect of fisheries disturbances on the nitrogen and phosphorus cycle, under different environmental conditions.

2.2.8 *Role and responsibility of partners*

NIOZ will act as WP2 leader. As WP leader NIOZ is in charge of and responsible for monitoring and supervising the proper execution of the WP with respect to work program and deliverables. IMARES (de Haan) will provide advice on the experimental set up of the electrical pulse system. IMARES will organise campaign 1 on board of RV Tridens during the BTS survey and will be involved in the SPI-data collection and analysis. ILVO will organise campaign 3 with the Simon Stevin and collect and analyse the multibeam data on the physical effects of the pulse trawling. WU will provide input based on the results of their experiments on the response of benthic invertebrates to electrical stimuli. The model developed by NIOZ to quantify the effect of electrical stimuli on benthic functioning will be made available to WP3 and WP4. Rijnsdorp (IMARES) as overall project coordinator will monitor and guide the work in relation to the links with the other WPs and in relation to the priorities formulated by the client.

2.2.9 *Research team*

Name	**Position**	**Institution**	**Role & Responsibilities**
[redacted]	Senior scientist	NIOZ	WP leader, main supervisor, modelling
[redacted]	Senior scientist	NIOZ	Supervisor
[redacted]	Senior scientist	NIOZ	Field campaigns 1-3
[redacted]	Senior scientist	NIOZ	Field campaign 2
[redacted]	Senior scientist	NIOZ	Field campaign 2
to be recruited	PhD student	NIOZ	Field and lab experiments,

Name	Position	Institution	Role & Responsibilities
			data analysis, reporting
	Research assistant	NIOZ	Field and lab experiments
	Research assistant	NIOZ	Field and lab experiments
	Junior scientist	IMARES	Field campaigns 1-3
	Researcher	IMARES	Setup Pulse system
	Senior scientist	IMARES	Global coordination

2.3 Workpackage 3. Sea bed: scaling up the effects of pulse trawling to the North Sea level

2.3.1 Summary

WP3 will develop a predictive model of the distribution of pulse trawl effort in relation to benthic habitats on the scale of the North Sea. To estimate the effect of pulse trawling on the catch and bycatch of target and non-target species, the model will be coupled to the models and results of WP1 and WP2 which predict the effect of electrical pulses on species and ecosystem functions. WP3 will respond to possible changes in the societal debate around the pulse trawl in a flexible way.

2.3.2 Background

Traditionally, flatfish are targeted with beam trawl gears using tickler chains. This fishery is characterised by substantial bycatches of undersized fish (particularly in the 80 mm sole fishery), high fuel consumption, and adverse effects on the sea bed habitat and benthic ecosystem. The pulse trawl is a promising alternative to replace the traditional tickler chain beam trawl. Research so far indicates a reduction in fish discards, a significant reduction in benthos by-catch, less seabed disturbance and significant fuel reduction (Quirijns et al. 2013). The commercial application of the pulse trawl, however, is hampered because to date EU-legislation does not allow fishers to use electric fishing gear. However, the EU has allowed the Netherlands to issue a limited number of temporary licences for pulse trawling. The derogation was issued with the specific task to carry out scientific studies on the effect of pulse trawling on marine organisms and the ecosystem. These studies will provide the scientific basis to evaluate the effects of pulse trawling and guide the decision making on the question whether pulse trawling can be accepted as a legal fishing method.

As part of the pulse trawl research programme, detailed laboratory investigations will be conducted to study the effects of electric pulses on the behaviour and injuries of fish and invertebrate species (WP1). Field experiments will be conducted to study the effect of electricity on functional groups, such as bioturbators and filter feeders, and on geochemical processes (WP2). These studies adopt a mechanistic approach that allows predicting how the pulse stimulus of commercial trawls affect individual organisms or ecosystem functions.

To assess the effects of pulse trawling on the North Sea scale, an integrative framework is required that takes account of (i) the patterns in space and time of the exploited fish species, sea bed habitats and benthic ecosystems, and (ii) the distribution of the fishing fleet and the intensity at which the different benthic habitats will be trawled. The objective of this task is therefore to develop the quantitative tools to scale up the effect of the pulse trawl on individual organisms and functional groups to the level of the population and the ecosystem.

2.3.3 Objectives

To develop a predictive framework to scale up the effect of pulse trawling to the level of the population and the ecosystem.

2.3.4 Research tasks

- 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
- Develop a predictive model of the impact of pulse trawling and beam trawling on the benthic ecosystem
- Estimate the proportion of the catch of pulse trawls that is injured by the exposure to electrical stimulation.

2.3.5 Workplan

Task 3.1 Predictive model of the distribution of pulse and beam trawling in space and time

The choice of a fisher when and where to go fishing is determined by the availability of target species, the costs of fishing, and the price of the fish. All of these vary in space and time, and will be affected by management measures (Hilborn 1985; Gillis 2003).

The adults of the main target species of the flatfish fishery (sole, plaice) show seasonal migrations between spawning and feeding areas while the juveniles migrate from the shallow coastal nursery grounds to deeper waters further off-shore. These seasonal migrations result in predictable changes in the availability of fish at the scale of fishing areas in the southern and central North Sea (~100 km). Within these large scale areas, local aggregations of fish occur at a scale of ~10 km which may last for a couple of days to a few weeks (Poos et al., 2007; Rijnsdorp et al., 2011). Where these local aggregations occur is unpredictable.

It is well established that bottom trawling is heterogeneously distributed in space, with some areas being trawled quite intensively and other areas trawled only lightly or not at all (Rijnsdorp et al., 1998; Lambert et al., 2012; Ellis et al., 2014). The patchy distribution of fishing effort is related to local aggregations of fish and to the distribution of trawlable grounds. Fish tend to form temporary aggregations, probably in response to the density of their food resources (Shucksmith et al. 2006), which cause fishers to concentrate their fishing activities on these local hot spots (Poos et al. 2007; Rijnsdorp et al. 2011; Ellis et al. 2014).

The sea bed is shaped by geological and hydrodynamic processes and is a mosaic of structures that vary in depth of the water column and sediment type. Fishers adjust their fishing gear to the sea bed in order to maximise catch efficiency while minimizing the risk of damaging the gear. As a result, the distribution of fishing effort over the various sea bed habitats differs across fishing gears (BENTHIS project; Eigaard et al. in prep). There are indications that pulse trawls fish in habitats that are less suitable for tickler chain beam trawls. As gears will differ in their relative catch efficiency for the mix of commercial fishes targeted, the profitability of fishing grounds will differ across fishing gears.

For the assessment of benthic impacts of fisheries, a study of the fine scaled distribution of pulse trawl and the traditional beam trawl in relation to the characteristics of the sea bed habitat and the catch efficiency for the species mix targeted is needed to unveil the underlying mechanism of the difference in habitat association and difference in distribution. Once the main factors determining the spatial distribution patterns of pulse and beam trawls are known, a mechanistic fleet dynamic model will be built to predict the distribution of trawling effort given the catch efficiency profile and habitat association profile of the gear.

The fleet dynamic model will follow a two-step approach. In the 1st step, a Dynamic State Variable Model (DSVM) will be developed to model the distribution of fishing effort on a large scale reflecting the predictable migration patterns of the target species. DSVM offers a particularly powerful mechanistic modelling instrument to study the dynamic choices of fishers that operate under management constraints (Clark and Mangel 2000, Gillis et al. 1995, Poos et al. 2010). DSVMs have been developed for demersal fisheries to address spatial distribution of fishing effort and discarding decisions (Poos et al. 2010, Batsleer et al. 2013). A DSVM will allow forecasting changes in spatial distribution of trawling impact as a result of a transition to pulse gears. It does so by combining the biology of the target species and the economics of the fishery. With respect to the biology, the model will have a detailed representation of the spatial and temporal variation in the size structured commercial fish populations. With respect to the economy, the model will take into account the difference in variable costs between traditional gear and pulse gear, as well as their relative catch efficiency. In the 2nd step the statistical distribution describing the patchy distribution of fishing effort in relation to the mosaic of sea bed habitats within each spatial units of the DSVM model will be applied to estimate the trawling intensity required to estimate the impact on the benthic ecosystem.

Task 3.2 Predictive model of the impact of pulse trawling and beam trawling on the benthic ecosystem at the scale of the North Sea

Estimates of the overall effect of fishing on the benthic ecosystem require maps of fishing spatial effort distribution (developed under research task 1) to be combined with impact maps quantifying the local sensitivity of the benthic ecosystem to trawling. The sensitivity of the benthic ecosystem to various types of bottom trawls varies in space and time, depending on the species composition. Benthic ecosystems are characterised by a high species richness, which complicates species-level studies of ecosystem effects, especially over large spatial scales. However, sensitivity to trawling ultimately depends on the properties of organisms (epi- infauna, brittle/solid, etc.), not on their taxonomy. Hence, we adopt a biological traits approach (Bolam et al 2014; input from BENTHIS project), where the species assemblage is described in terms of its ecological function, life history parameters and morphological characteristics. A trait-based approach also facilitates extrapolation of species-level sensitivity experiments of pulse- and conventional trawls (PhD 2) to a wider set of species, by analysing which traits convey sensitivity or resistance to trawling.

The distribution of biological traits in space is also linked to other biotic and abiotic conditions such as productivity, depth, natural disturbance and sediment characteristics (Bolam et al 2014; van Denderen et al., 2016). By combining data on these factors with trawling intensity, we will develop statistical models of impact on specific ecosystem functions. These models can be used to draw maps of the North Sea showing the distribution of potential impact per unit effort of pulse trawls, and the difference with conventional beam trawl gear.

Task 3.3 Catch proportion injured by exposure to the pulse stimuli

By combining the results of the sensitivity of specific species (PhD 1) with distribution maps of these species (based on IMARES and ICES fish survey data of the North Sea), the observed distribution of the pulse trawl fleet and the catchability of the pulse gear (comparative fishing experiments), the proportion of fish adversely affected (injured) will be estimated, making a distinction between the fish that escape through the meshes, and those that are retained. Particular attention will be given to the catch of *Raja clavata* and other rays and skates as these may be particularly sensitive for the pulse fishery. In order to assess how often an organism may be exposed to a pulse stimulus, the frequency distribution of the time interval between successive exposures will be estimated.

2.3.6 Role and responsibility of partners

IMARES will act as WP3 leader. As WP leader IMARES is in charge of and responsible for monitoring and supervising the proper execution of the WP with respect to work program and deliverables.

WU will provide the model of the electric field to be used to predict the effects on fish and benthic organisms. NIOZ will provide the model to quantify the effect of electrical stimuli on the functioning of the benthic ecosystem and will be involved in the scaling up to the scale of the North Sea. Both models will be incorporated in the model tools developed in WP3 to carry out the impact assessment in WP4.

2.3.7 Time line

		2016				2017				2018				2019			
	Task	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
WP3	3.1																
	3.2																
	3.4																

2.3.8 Deliverables

1. Manuscript on predicting the small scale distribution of pulse and beam trawling in relation to sea bed habitat
2. Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the benthic ecosystem
3. Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the discarding

2.3.9 Research team

Name	**Position**	**Institution**	**Role & Responsibilities**
[redacted]	Senior scientist	IMARES	WP Leader, impact assessment
[redacted]	Scientist	IMARES	VMS analysis and modelling
[redacted]	Scientist	IMARES	Fleet dynamic modelling, impact assessment
[redacted]	Scientist	IMARES	Modelling effects benthic ecosystem
[redacted]	Junior scientist	IMARES	Elasmobranch
[redacted]	Junior scientist	IMARES	Discard sampling, monitoring fractures
[redacted]	Senior scientist	ILVO	advice
Post doc		IMARES	Modelling effects benthic ecosystem

2.4 Workpackage 4 Impact assessment

2.4.1 Summary

This Work Package will provide the synthesis of the results of the project and apply the predictive models developed in WP1 to WP3 to estimate the effects of the transition of the flatfish fishery from the traditional beam trawl gear to the pulse trawl.

2.4.2 Objectives

Perform an impact assessment of the transition of the Dutch flatfish fishery from a traditional beam trawl fleet to a pulse trawl fleet.

2.4.3 Research tasks

- Assess the ecological consequences of the transition from beam trawling to pulse trawling for flatfish.

2.4.4 Workplan

Task 4.1 Assessment of ecological consequences of the transition from beam trawling to pulse trawling for flatfish

The fleet dynamic model developed in WP3 will be used to estimate the distribution of fishing effort for conventional beam trawlers, and for pulse trawlers. This will be done at the scale that is appropriate to estimate the impact of both gear types on the benthic ecosystem. 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. A range of effort distribution maps for a variety of management assumptions can be computed. These effort distribution maps will be combined with the potential impact maps for non-target fish and benthic invertebrates. The combination of effort distribution maps and impact maps result in spatially explicit impact estimates on benthic invertebrates and non-target fish, under a variety of management scenarios and pulse gear settings.

The model will also be used to (i) estimate the bycatch of undersized fish to assess the extend to which the gear transition affects the amount of discards, and (ii) to provide population level estimates of injuries in different fish populations.

2.4.5 Role and responsibility of partners

The project coordinator of IAPF (IMARES) will be scientist in charge of WP4 and as such responsible for monitoring and supervising the proper execution of the WP with respect to work program and deliverables. The models developed by WU (WP1), NIOZ (WP2) and integrated with the models developed by IMARES (WP3) will be applied to carry out the impact assessment. The lead scientist of WP1 (WU), WP2 (NIOZ) and WP3 (IMARES) will provide a summary of the main results of the studies conducted in WP1, WP2 and WP3. The lead scientist of IMARES will integrate these inputs with the results of the impact assessment, collaboration with lead scientist of NIOZ, WU and ILVO.

2.4.6 Deliverables/time line

Final report in English summarising the results of the different WPs, and synthesising the describing the synthesis of the results and a quantitative assessment of the transition of the traditional beam trawl fleet to a fleet with only pulse trawlers. This report also provides an executive summary in Dutch of the results arising from workpackages 1, 2 and 3.

2.4.7 Research team

Name	Position	Institution	Role & Responsibilities
[redacted]	Senior scientist	IMARES	WP Leader, input from WP3, impact assessment
[redacted]	Senior scientist	IMARES	Impact assessment
[redacted]	Senior scientist	WU	Summary results of WP1
[redacted]	Senior scientist	NIOZ	Summary results of WP2
[redacted]	Senior scientist	ILVO	Advice

2.5 Overview of project deliverables

No.	WP & task	Title	Nature	Delivery month	Responsible partner	Dissemination level
1	1.1	A model-framework for simulating spatio-temporal characteristics of electrical fields generated by pulse fishing gear in different environments.	Model	12	WU	internal
2	1.2	A model-framework for linking external electrical fields to internal current flow in a diverse group of animals.	Model	24	WU	internal
3	1.3	Report on susceptibility of marine invertebrates to electrical pulses.	Report	36	WU	Public
4	1.4	Report on behavioural responses in different groups of fish to low amplitude electrical pulses.	Report	42	WU	Public
5	1.5	Report on effects of electrical pulses on behaviour in elasmobranchs	Report	48	WU	Public
6	1.6	A model framework for numerical simulations of pulse fishing effects; specificity of catches, bycatches and collateral damage.	Model	42	WU	internal
7	1.7	Report on damaging effects in roundfish bycatch by electrical fishing on the basis of Xray photographs	Report	36	WU	Public
8	2.1	Data set and manuscript on the short-term effects of sediment disturbances induced by electrical currents and mechanic stirring (experiments in campaign 1).	Data set Manuscript	33	NIOZ	Public
9	2.2	Data set and manuscript on *in situ* effects of pulse and beam trawl fisheries (campaign 2).	Data set Manuscript	36	NIOZ	Public
10	2.3	Data set and manuscript on long-term effects of fishing on sediment biogeochemistry in the Southern Part of	Data set Manuscript	42	NIOZ	Public

No.	WP & task	Title	Nature	Delivery month	Responsible partner	Dissemination level
		the North Sea (campaign 3).				
11	2.4	The process-based mathematical model. Quantification of the local effect of fisheries disturbances on the nutrient cycles, under different environmental conditions.	Model	36	NIOZ	Public
13	3.1	Manuscript on predicting the small scale distribution of pulse and beam trawling in relation to sea bed habitat	Manuscript	18	IMARES	Public
14	3.2	Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the benthic ecosystem	Manuscript	48	IMARES	Public
15	3.3	Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the discarding	Manuscript	36	IMARES	Public
16	3.4	Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the benthic ecosystem	Paper	48	IMARES	Public
17	3.5	Manuscript on the effect of a transition from the beam trawl to the pulse trawling on the discarding in the Dutch flatfish fishery	Paper	36	IMARES	Public
18	4	Final report in English summarising the results of the different WPs, and synthesising the describing the synthesis of the results and a quantitative assessment of the transition of the traditional beam trawl fleet to a fleet with only pulse trawlers	Report	48	IMARES	Public
19	5	Progress Report Year 1	Report	12	IMARES	Confidential
20	5	Progress Report Year 2	Report	24	IMARES	Confidential
21	5	Progress Report Year 3	Report	36	IMARES	Confidential
22	5	Progress Report Year 4	Report	48	IMARES	Confidential

2.6 Communication

2.6.1 Communication with the Ministry of Economic affairs

Representatives of the consortium and the Ministry of Economic affairs will meet four times per year (3 months interval) to present and discuss progress of the project. Assuming that the project starts in January 2016, it is anticipated that the four annual project progress meetings will be held in January, April, July and October. Exact meeting dates will be fixed well in advance by the coordinator in liaison with the Ministry and the other consortium members. The Ministry will in priniciple be the meeting venue, unless decided otherwise by the Ministry and the consortium.

At the end of each project year the consortium prepares a written "tussenrapportage" according to specifications to be provided by the Rijksdienst voor ondernemend Nederland (RVO). A total of four "tussenrapportages" will be prepared. Assuming that the project starts in January 2016, it is anticipated that these annual reports will be submitted to the Ministry in December of the years 2016 to 2019.The coordinator will present the annual "tussenrapportage" at the first progress meeting of the next project year.

Project results will also be communicated through reports and papers as described in section 2.6.

2.6.2 External communication

Progress of the research activities will be presented and discussed with the International Pulse Trawl Advisory Board that will be established by the client.

To comply with EU directive 508/2014 the objectives and results of this project will be disseminated beyond the fisheries sector. To this end results of the project will be presented at regular international scientific fora such as the ICES Annual Science Conference, World Fisheries Congres, International Flatfish Ecology Symposium, International conference Measuring Behavior, and at the ICES Working Group on the Electrical Trawling (WGELEKTRA).

All reports, publications and presentations of this project will be made available to the pulse portal www.pulsefishing.eu

To inform the fishing sector and other stakeholders about the progress amde, the coordinator will write articles at least on an annual basis that will be submitted to be Visserijnieuws and Fishing News.

All partners will include the EU logo and the EFMZV slogan to acknowledge the funding agencies when presenting their results at meetings.

3 Management plan

3.1 Project management structure

The project management structure is based on the execution of the project by the consortium of four partners and the organization of the research in work packages.

Project management is organized at five levels:

1. Overall project management and coordination
2. Project steering committee
3. Work package management
4. Supervision of Ph.D. candidates
5. Partner's internal management

Level 1 Overall project management – coordination

IMARES will act as project coordinator. This means that IMARES is responsible for the overall operational management of the project. Within the operational management of the project, two main fields are distinguished: management of the research program and financial & administrative management. Within IMARES the management of the research program will be assigned to a Research coordinator and the financial & administrative management will be assigned to an Administrative manager.

Key tasks and responsibilities of the Research coordinator include:

- Representing of the consortium towards the Ministry of Economic Affairs (EZ), communicate and correspond with EZ on behalf of all partners.
- Monitoring and steering the progress of the research program towards its deliverables.
- Facilitating cooperation between work packages.
- Prepare and edit the scientific contributions of partners to the annual Progress reports (Tussenrapportages) according to the specifications of the EZ.
- Chair the project's steering committee.

Key tasks and responsibilities of the Administrative manager include:

- Representing the consortium towards RVO, communicate and correspond with RVO on financial and administrative matters on behalf of all partners.
- Inform and instruct partners on financial and administrative matters
- Organisation of project meetings
- Prepare and edit the financial and administrative contributions to the annual Progress reports (Tussenrapportages).
- Coordinate, support and instruct partners in their financial and administrative contributions to the annual Progress reports.
- Submit the Progress reports to RVO
- Coordinate the distribution of the project's financial contributions among the partners.

[redacted] will be appointed as Research coordinator.

Administrative management will be the responsibility of [redacted] of IMARES. During the last 10 years he gained significant management experience in a number of large and complex national research projects as well as international EU research projects.

Level 2 Project steering committee

The Steering committee is the project's decision making body. The Steering committee will consist of representatives of all four consortium partners and will be chaired by the Research coordinator (Table 3.1). The other members of the Steering committee are the Administrative manager, the Work package leaders and a representative of partner ILVO. The main responsibility of the Steering committee is to monitor and safeguard the execution of the research according to its program. Key tasks and responsibilities of the Steering committee include:

- Provide the project with a decision making body.
- Monitoring the progress of the research.
- Monitoring the quality of the research
- Connecting the work packages and facilitating cooperation between them

Table 3.1 Composition of the Steering committee

Partner	Representative	Roles in the project	Role in Steering committee
IMARES	[redacted]	Research coordinator, WP3 and WP4 leader	Chair & partner representative
IMARES	[redacted]	Administrative manager	Advisor
NIOZ	[redacted]	WP2 Leader, promotor Ph.D candidate of WP2	Partner representative
WU	[redacted]	WP1 Leader, promotor Ph.D candidate of WP1	Partner representative
ILVO	[redacted]	Partner in WP1, 2 and 3	Partner representative

Level 3 Work package management

The research program is organized in four work packages. Within each work packages tasks have been defined, including their timing and relation to other tasks. Within each task the contributions of each partner are defined and described. For each work package deliverables (results) have been defined, including their content and the timing of their delivery. All this is described in chapter 2 Activities.

A work package leader will be assigned to each work package (Table 3.2). The work package leader is a representative of the consortium partner that will perform most of the research within the respective work package. The Work package leader functions as manager for his or her work package and reports to the Research coordinator. The Work package leader is in charge of and responsible for organizing, monitoring and supervising the proper execution of the tasks within the work package. This includes the preparation of a detailed work plan for the work package, timely initiation and completion of tasks, the timely completion of deliverables and the quality of the content of the deliverables. It also includes management of the contributions of other partners to the research program of the work package and management of deviations from the research program. A Work package leader can delegate tasks to competent colleagues.

Table 3.2 Work package leaders

Work package	Workpackage leader	Partner
1		WU
2		NIOZ
3		IMARES
4		IMARES

Level 4 Supervision of Ph.D candidates

Upon request of the Ministry of Economic Affairs a large part of the research will be carried out by Ph.D candidates. Ph.D candidates will be employed by the respective consortium partners. As such the core of each work package consists of a PhD or Post doc research program that will contribute significantly to the research programs of the work packages. To avoid conflicts of interest between the Ph.D candidate and the work package, supervision of the Ph.D candidates will be the responsibility of the Work packages leaders.

PhD candidates at WU will take part in the WIAS research school and will fulfil the requirements for WIAS PhD training. This includes compulsory and optional courses at WUR and/or external courses. Funding for PhDs is for four years, in which time they finish research papers and a PhD thesis. The initial appointment will be for one year, which is extended to 4 years unless progress within the first year is considered insufficient.

Partner's internal management. Each partner carries its own responsibility for an adequate internal organization and management structure in relation to this project. Each partner will assign a Partner Representative who carries final responsibility for both the scientific and the administrative management of all tasks assigned to his or her organisation (defined in work packages descriptions). Within his or her organization the Partner representative can delegate responsibilities to competent colleagues. However, in all cases Partner representatives will be the contact persons for his or her organisation towards the other partners, the Research coordinator and the Administrative management. To keep things as simple as possible, Work package leaders will also act as Partner representatives.

3.2 Management procedures and internal communication flow

Day-to-day decision-making. Day to day decision making concerning minor issues related to the performance of the research as defined in the work package descriptions will be the responsibility of the Work package leaders. As such the work packages can be efficiently management by their work package leaders.

For major issues, such as deviations from the original work package description or other issues (judged by the Work package leader) decision making is the responsibility of the Steering committee.

Plenary project meetings. Representatives of all partners will meet at least annually to review project results, progress and activities of the past period and planning of activities for the coming period. Responsible partners will report on their work during these meetings. Additional plenary project meetings can be organized when deemed necessary.

Steering committee meetings. These meetings will be organised parallel to the Plenary project meetings. Extraordinary Steering committee meetings may be organized if needed.

Technical meetings. These meetings will be organized on work package level by work package leaders as required. Technical meetings only involve partners directly involved in the respective work packages.

3.3 Quality

IMARES utilises an ISO 9001:2008 certified quality management system (certificate number: 124296-2012-AQ-NLD-RvA). This certificate is valid until 15 December 2015. The organisation has been certified since 27 February 2001. The certification was issued by DNV Certification B.V. Furthermore, the chemical laboratory of the Fish Division has NEN-EN-ISO/IEC 17025:2005 accreditation for test laboratories with number L097. This accreditation is valid until 1th of April 2017 and was first issued on 27 March 1997. Accreditation was granted by the Council for Accreditation.

Research at Wageningen University is organized in research schools. Each school is accredited every 6 years by ECOS-KNAW. Research visitations at Wageningen University are part of a nation-wide program, in which each university is committed to external reviewing every 6 years. In addition there are regular half-term reviews. All reviews are conducted according to standard evaluation protocols (SEP) of KNAW, NWO and VSNU.

ILVO has grouped all its testing laboratories into the ILVO-ANIMALAB, short for the Animal Marine Laboratory. Every laboratory in ILVO-ANIMALAB works according to the criteria of the NBN EN ISO/IEC 17025 standard. This standard and the Belgian accreditation system 'BELAC' gives laboratories, certification institutions, and inspection bodies shows a laboratory's expertise and increases its credibility at the national and international levels. The scope of accredited analyses can be consulted on the BELAC website under certificate number T-315.

3.4 Quality risks and contigency plan

There are a number of risks and contingencies that may jeopardise the successful accomplishment of the objectives of IAPF. The risks are reviewed below. The Project managament will review the risks and contingency planning annualy and if problems arise will interact with the lead scientist of each partner to find a solution.

If no suitable PhD-candidate can be employed in a reasonable time period, a postdoc will be employed.

The success of the field studies (campaign 1, 2 and 3) in WP1 will depend on the weather conditions. Field campaigns will be planned in months where the risk of bad weather is low. In addition, to further reduce the risk of losing ship time, we will combine campaign 1 with the annual beam trawl survey performed by IMARES. This cost effective combination will provide a larger number of days at sea in comparison with a single trip as we will not lose time to sail to the sampling locations.

The exposure experiments in WP1 require a permit from the 'Wet op de Dierproeven'. The risk of not being granted permission to carry out the experiments is reduced by planning the experiments both in the Netherlands and in Belgium. To avoid delay in acquiring the necessary permits, the procedure to obtain permits will be started immediately after the start of the IAPF project.

Experiments in WP1 are partly planned in Wageningen and/or Yerseke. Planning these experiments depends on availability of research facilities. It is unclear which facilities will remain in Yerseke. Also, availability in Wageningen is not unlimited. Experiments also depend on availability of specimens. Planning and timing of experiments will therefore have to be flexible.

Collaboration with the Dutch fishing industry is required for the successful completion of the research tasks in WP1 and WP2. The coordinator of IAPF will closely monitor any problems with the contribution of the fishing industry. In case of problems, the coordinator will contact representatives from EZ and the fishing industry to resolve these.

To enhance the flow of information between the research tasks, in particular the flow of information from WP1, WP2 and WP3 towards WP4, project meetings will be organised by the coordinator twice a year.

3.5 Confidentiality

The results of this project will be made public by publication in scientific journals and through the internet.

3.6 Organization / collaboration

3.6.1 Consortium

The research will be carried out by a consortium that consists of IMARES, NIOZ, WU and ILVO. These parties are independent research institutions that maintain the highest scientific standards in their work. The consortium brings together international specialists with excellent reputations that cover the wide variety of scientific expertise required to fullfil the aims of the proposed research. Scientific expertises range from animal physiology and morphology, benthic ecosystem processes, ecosystem effects of fishing, modelling of populations and ecosystem, modelling effort allocation of fishing fleets.

The consortium is based on ongoing collaboration between the partners on projects that are currently being carried out on related topics. As a result knowledge that is being developed in these projects but not yet publically available, can be used in this project. For instance, ILVO and IMARES are collaborating in the FP7-BENTHIS project (2013-2017) to study the impacts of pulse trawling on the benthic ecosystem in the North Sea. IMARES is monitoring the discard rates of pulse and beam trawlers and is involved in studies of the survival of bycatch species in the pulse fishery. IMARES has a pulse generator that simulates a wide range of pulse characteristics which can be applied in exposure experiments. Detailed descriptions of these parties and the staff they will involve in this project is provided in section 3.5.

3.6.2 Roles and responsibilities within the consortium

The consortium will be led by IMARES. In addition, IMARES will act as workpackage leader and be responsible for the deliverables of WP3 and WP4. IMARES will be the cruise leader of campaign 1 in WP1 in collaboration with NIOZ.

WU will act as workpackage leader of WP1 and be responsible for the deliverables specified for this workpackage. WU will provide input to the modelling of the electric fields and the impact on marine organisms in WP3 and privde input to the final report in WP4.

NIOZ will act as workpackage leader of WP2 and be responsible for the deliverables specified for this workpackage. NIOOZ will provide input to the experiments with benthic invertebrates conducted in WP1 and provide input to the modelling of the effect on the benthic ecosystem in WP3 and the final report in WP4.NIOZ will be the cruise leader of campaign 2.

ILVO is responsible for setting up of the tank experiments in WP1, which will be carried out in Oostende, and the field campaign 3 with the Simon Stevin in WP2. ILVO will further provide input to the final report to be made under WP4. ILVO will be the cruise leader in campaign 3 in collaboration with NIOZ.

Cooperation among partners within the four workpackages, including the resulting roles and responsibilities are described in detail in the Section 2 Activities of this tender document. Each partner carries responsibility for the timely and proper execution of its assigned project tasks within the allocated budgets. The cooperation between IMARES, NIOZ, WU and ILVO in this project will be formalized in a consortium agreement (samenwerkingsovereenkomst). The consortium agreement will be signed by authorized representatives of all partners upon the start of this project.

3.6.3 Collaboration outside the consortium

Collaboration with the Dutch fishing industry is required to provide biological samples for WP1 and to generate a trawling gradient to study the impact of ecosystem functioning in WP2. The coordinator will be responsible for facilitating the planning. The details of the planning will be the responsibility of the cruise leaders of the campaign.

3.6.4 Use of PhD students and Post-docs

WP1 and WP2 will be carried out by PhD-student as this will provide most working hours that are needed to carry out the laborious experiments and modelling work. If no suitable candidates can be found in time, a post-doc may be hired. WP3 is focussed on the development of the tools required to integrate the results of WP1 and WP2 and to provide the tools to carry out in WP4 the impact assessment of the ecological consequences of a replacement of the beam trawl gear with the pulse gear. WP3 will be carried out partly by a postdoc and partly by IMARES staff. This will enhance the flexibility and warrant a better control of the research activities aimed at providing the most useful science input in the regular interactions with the stakeholders, both on the national and international level. WP4 will be carried out by IMARES in collaboration with WU, NIOZ and ILVO to warrant a result that is supported by all groups involved in the project.

3.7 Description of consortium partners

3.7.1 IMARES Wageningen UR

General

IMARES (Institute for Marine Resources and Ecosystem Studies) conducts applied research on marine ecosystems as a basis for sustainable management. The scientific staff (~ 100 researchers) cover a wide variety of expertise's in fisheries science, fishing technology, benthic ecology, marine resource management and theoretical ecology and have successfully developed collaborative research with the fishing industry. The institute is active in international organisations such as ICES, STECF, EFARO and contributes to the scientific basis for fisheries and marine management. The institute has a long history in research on pulse trawl starting in the 1970s (Boonstra and de Groot, 1970). More recently IMARES has conducted experiments in which a variety of marine organisms were exposed to electrical pulses (overview in Quirijns et al., 2013) and conducted a comparative fishing experiment of two pulse trawlers and one beam trawler (van Marlen et al., 2014).

IMARES is the overall coordinator and leader of WP3 and WP4.

Personel

Publications

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3.7.2 Royal Netherlands Institute for Sea Research (NIOZ)

General

The Royal Netherlands Institute for Sea Research is the National Oceanographic Institute of the Netherlands and part of the Netherlands Organization for Scientific Research (NWO). Since January 2012 the former Centre for Estuarine and Marine Ecology (CEME) of the Netherlands Institute of Ecology (NIOO-KNAW) has officially merged with the NIOZ. As a result, the NIOZ now has a division located in Texel and one in Yerseke, employs around 300 people and has an annual budget of approximately €40 million. The mission of NIOZ is to gain and communicate scientific knowledge on seas and oceans for the understanding and sustainability of our planet, and to facilitate and support marine research and education in The Netherlands and Europe.

The NIOZ has a long tradition in experimental, field work and modelling, more specifically in the field of benthic-pelagic coupling and the deployment of benthic landers. Recent work focused on benthic-pelagic coupling and nutrient cycles in the North Sea (Braeckman et al., 2014; Le Guitton et al., 2015). NIOZ also participated in studies on the impact of bottom trawls in which beam trawls and pulse trawls were studied (IMPACT, REDUCE).

Personel

[redacted]

[redacted]

Selected publications

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3.7.3 Wageningen University

General

The Experimental Zoology group is part of the Department of Animal Sciences of Wageningen University. The group combine physics, engineering, molecular techniques and modelling in a quantitative systems-analysis to solve complex fundamental and applied problems in zoology, develops novel insights into the biomechanics and developmental mechanics of animal locomotion, and translate elucidated biological mechanisms into solutions for animal and human health problems, and technological problems in robotics.

Personel

[redacted]

[redacted]

[redacted]

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3.7.4 ILVO

General

ILVO-Fishery is a public research organisation, depending from and supervised by the Ministry of the Flemish Community (Vlaams Gewest). ILVO-Fishery comprises three operational sections: Biology & Aquaculture, Monitoring and product technology and Fishing Gear Technology. The Fishing Gear Technology Section focuses on various aspects of the fish catching process, such as the development of new fishing gear, the improvement of the size and species selective properties of existing gears, alternative fishing methods, the reduction of fuel consumption and the reduction of the environmental impact of fishing activities. Research at the institute is strongly service-oriented towards international scientific organisations and management bodies, the Government, the fishing industry and the consumer. ILVO has participated in a number of EU-projects.

[redacted]

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3.8 Time schedule

The time schedule for the execution of the work packages and the tasks therein is given below. This time schedule assumes that the project starts on the first of January 2016. Each project year is split in four quarters. It is foreseen that the Ph.D students in work packages 1 and 2 can start their research mid 2016. The research activities of PhDs to WP3 and WP4 will be organised in such a way that their input to WP3 and WP4 will take place during the project, in order to allow WP4 to produce the final report at the end of 2019. The PhD activities in 2020 will be focused on the writing up of the PhD-thesis.