1.6.7.1 Request from France for updated advice on the ecosystem effects of pulse trawl

Advice summary

ICES concludes that:

1. Conventional beam trawling has significant and well demonstrated negative ecosystem impacts. If properly understood and adequately controlled, electric pulse stimulation may offer a more ecologically benign alternative and could reduce fishing mortality on non-target species. However, it is unclear whether the current legislative framework is sufficient to avoid the deployment of systems that are potentially harmful for some marine ecosystem components (e.g. cod). While the systems currently used do not appear to have major negative impacts, ICES considers that the existing regulatory framework is not sufficient to prevent the introduction of potentially damaging systems.

2. Technological developments have resulted in pulse trawl systems requiring less power (typically less than 1 kW per m gear width of beam length) and new trawl designs (SumWing, PulseWing) that reduce the pressure on the seabed. However, operational issues such as the determination of critical pulse characteristics (power, shape, frequency, etc.) to determine thresholds which ensure environmental sustainability, remain unresolved. ICES therefore advises to undertake structured experiments that are able to identify the key pulse characteristics and thresholds below which there is no evidence of significant long-term negative impact on marine organisms and benthic communities. ICES also recommends that as part of the regulatory framework, information on the pulse parameters used during fishing operations is made available to the scientific community as this information is needed to conduct assessments of the ecological impact of the pulse fisheries.

3. Questions remain for target and non-target species regarding delayed mortality and long-term population effects as well as sub-lethal and reproductive effects of electric trawls. Recent experiments on pulse trawling in saltwater conditions have expanded the knowledge base significantly (additional species, life stages, reproduction, feeding behaviour) and provided greater insight into more medium-term effects. It is unclear whether the injuries observed in cod are restricted to cod or potentially have an impact on all gadoids.

4. ICES recommends that a research programme should be set up to address outstanding issues, including long-term and/or cumulative effects of flatfish and shrimp pulse trawling.

5. ICES advises not to generalize from the results of the research carried out to date to allow expansion of the use of the pulse trawl outside the current area and fisheries allowed for in the current legislation. Extending the use of similar technology in other fisheries without a comprehensive environmental impact assessment would not be consistent with the precautionary approach. ICES considers that opportunities to trial fishing by electrical means in other fisheries should be made available in a structured, incremental way to allow for such impact assessments.

6. The risk of negative impacts on species and habitats covered by the Natura 2000 directives is considered low in the current area fished and with the current pulse characteristics.

Request

France request ICES to review the work of SGELECTRA and IMARES and to provide an updated advice on the ecosystem effects of the pulse trawl, and especially on the lesions associated and mortality for targeted and non-targeted species that contact or are exposed to the gear but are not retained on board, with special reference to those species covered by the Natura 2000 Directives, and on Natura 2000 habitats.

Supporting information:

French Natura sites of relevance include those that correspond to depths/areas trawled by pulse trawls (http://natura2000.eea.europa.eu/#). These habitats will include, for example, "shallow sandbank" and any effects on sub-habitats and indicator species e.g. sandeels or certain molluscs, see http://inpn.mnhn.fr/docs/cahab/tome2.pdf (see from p43 onwards for sandbanks). The following species and habitats are relevant (consideration should not necessarily be limited to them):

Natura Habitats

- *Sandbanks which are slightly covered by sea water all the time*
- *Estuaries*
- *Mudflats and sandflats not covered by seawater at low tide*
- *Coastal lagoons*
- *Large shallow inlets and bays*
- *Reefs*
- *Submarine structures made by leaking gases*

Natura Species:

- *Petromyzon marinus (Sea lamprey)*
- *Lampetra planeri (Brook lamprey)*
- *Lampetra fluviatilis (River lamprey)*
- *Alosa alosa (Allis shad)*
- *Alosa fallax (Twaite shad)*
- *Salmo salar (Atlantic salmon)*
- *Tursiops truncatus (Bottlenose dolphin)*
- *Phocoena phocoena (Harbour porpoise)*
- *Lutra lutra (Otter)*
- *Halichoerus grypus (Grey seal)*
- *Phoca vitulina (Common seal)*

Elaboration on the advice

1. Conventional beam trawling has significant and well demonstrated negative ecosystem impacts. If properly understood and adequately controlled, electric pulse stimulation may offer a more ecologically benign alternative and could reduce fishing mortality on non-target species. However, it is unclear whether the current legislative framework is sufficient to avoid the deployment of systems that are potentially harmful for some marine ecosystem components (e.g. cod). While the systems currently used do not appear to have major negative impacts, ICES considers that the existing regulatory framework is not sufficient to prevent the introduction of potentially damaging systems.

   Previous work (ICES, 2012) has highlighted that pulse trawls, compared to conventional beam trawls, tend to have a lower catch per unit of effort (cpue) for both plaice and sole and a range of other species. Pulse trawls are generally less efficient in comparison to conventional beam trawls due to a combination of lower catchability and towing speed, meaning that the spatial footprint per hour of fishing is less than conventional gears.

   New studies (ICES, 2016; van Marlen *et al.*, 2014) indicate that pulse trawls also catch fewer benthic organisms (about 80% in benthos per unit area, and 62% per hour) compared to the conventional beam trawl. Most of the benthos bycatches consisted of epifauna species. When looking into species composition the pulse trawl caught 75% less epifauna per area, and 58% less per hour. However, given lack of information at the fleet level on the design of the pulse system configurations and in particular the presence or absence of tickler chains, it is not possible to determine whether there are any significant reductions in unaccounted mortality of epifauna that contact but are not retained by the gear, beyond the reductions that would be associated with the reductions in swept area.

In close cooperation with the Dutch government, inspection agencies and the fishing industry, a set of revised technical requirements were defined for pulse fishing gear for flatfish as currently used in the Dutch fisheries. The idea behind this change is that variables to control should be measurable during inspections on-board fishing vessels. Based on the present state of knowledge, and subjected to review in the future, limits for flatfish gears that should be defined are:

- Maximum V_{peak},
- Minimum distance of electrodes,
- Maximum electric power in kW per m length,
- Maximum duty cycle (ICES, 2016).

The change from field strength to peak voltage would enable inspections on board. The process of defining an adequate set of rules and testing them in practice is still continuing. These Technical Specifications have not yet been implemented as part of the licence requirements (ICES, 2016).

ICES observes (ICES, 2016) that 84 licences have now been issued to use pulse trawl in the Netherlands for scientific research and data collection purposes. This is well in excess of the 5% limit included in the original legislation (EU, 2007). The increases in the number of licences issued were agreed at EU level in 2010 and 2014 (Haasnoot *et al.*, 2016). ICES has no basis to conclude whether this level is appropriate or not, although it would seem over and above levels that would normally be associated with scientific research.

2. Technological developments have resulted in pulse trawl systems requiring less power (typically less than 1 kW per m gear width of beam length) and new trawl designs (SumWing, PulseWing) that reduce the pressure on the seabed. However, operational issues such as the determination of critical pulse characteristics (power, shape, frequency, etc.) to determine thresholds which ensure environmental sustainability, remain unresolved. ICES therefore advises to undertake structured experiments to identify the key pulse characteristics and thresholds below which there is no evidence of significant long-term negative impact on marine organisms and benthic communities. ICES also recommends that as part of the regulatory framework, information on the pulse parameters used during fishing operations is made available to the scientific community as this information is needed to conduct assessments of the ecological impact of the pulse fisheries.

   A set of Technical Specifications has been developed by the Dutch government which are to be implemented as part of the licence requirements for the Dutch flatfish pulse trawl fishery in the course of 2016 (ICES, 2016). In these Technical Specifications parameters including maximum V_{peak}, minimum distance of electrodes, maximum electric power in kW per m beam or wing length, and maximum duty cycle have all been identified as critical. However, a justification for the selection of these parameters and why other parameters that may lead to different impacts have not been considered (e.g. pulse shape) is lacking. Research that would allow conclusions to be drawn on whether the current proposed limits are sufficient or not has only been partially carried out. Extensive laboratory tests by Soetaert (2015) and de Haan *et al.* (2015) on responses of fish and invertebrates to homogenously distributed electrical fields with varying values, including those exceeding the ones mainly used in the flatfish fishery, indicate that no irreversible side effects of the electrical stimulation are to be expected in sole and dab. For shrimp no effects on mortality, egg loss, and moulting behaviour were observed. The studies on invertebrates suggest there is no reason to assume that the effects of electrical stimulation on invertebrates has a larger impact than that from conventional mechanical stimulation (ICES, 2016).

3. Questions remain for target and non-target species regarding delayed mortality and long-term population effects as well as sublethal and reproductive effects of electric trawls. Recent experiments on pulse trawling in saltwater conditions

have expanded the knowledge base significantly (additional species, life stages, reproduction, feeding behaviour) and provided greater insight into more medium-term effects. It is unclear whether the injuries observed in cod are restricted to cod or potentially have an impact on all gadoids.

Recent experiments on pulse trawling, with current characteristics in saltwater conditions, have expanded the knowledge base significantly (additional species, life stages, reproduction, feeding behaviour) and provided greater insight into more medium-term effects. Extensive experiments have been conducted across a wider range of fish and benthic species. These largely confirm that the direct (and potentially lethal) impacts on the main target and some of the non-target species are minimal. The exception is spinal damage of (large) cod (*Gadus morhua* L.). In summary, the main studies showed that there are no direct links between lesions in dab (*Limanda limanda* L.) and pulse fishing (De Haan *et al.*, 2015), that electrical stimuli show little effect on larval stadia of sole (Desender *et al.*, 2015b), and that there is no long-term impact of the electrical stimulus used in the current flatfish and shrimp pulse trawls on the reproduction and behavioural response of elasmobranchs, which are electrosensitive species that use electroreceptors. Examples of the latter are dogfish, e.g. *Scyliorhinus canicula* (de Haan *et al.*, 2009) and rays, e.g. *Raja clavata* (Desender *et al.*, 2015a). However, experiments involving elasmobranchs have been limited to a few species and a very small number of individuals (Soetaert, 2015). Exploratory studies show that the effects of pulse trawl on invertebrates is lower than that of conventional beam trawl (de Haan *et al.*, 2009).

Negative impacts were found with respect to spinal damage of cod. Further studies largely confirm what was already known. Large cod (34–56 cm) are particularly susceptible to spinal damage while cod of 11–17 cm do not appear to suffer to the same degree or indeed at all (de Haan *et al.*, 2016). Spinal damage was also observed in discard-sized cod (20, 23, 27 cm) caught in a commercial pulse trawl (van Marlen *et al.*, 2014). If the large cod are to be retained, the spinal injury is an ethical issue (and for fishers a potential economic issue due to lower market prices) rather than a biological one. In recent years technical regulations have attempted to limit catches of all cod in beam trawls (by introducing large mesh panels). It is possible that spinal injuries may result in a reduction in the numbers of large cod that would otherwise have escaped via these large mesh panels. It is yet unclear whether spinal injuries are restricted to cod or potentially have an impact on all gadoids. Additional investigations on sea bass show that spinal injuries are likely to be species-specific across gadoid species (Soetaert, 2015).

Discard survival studies (van Marlen *et al.*, 2015) are currently being conducted, indicating that short-term survival in pulse trawls of sole (*Solea vulgaris* L.) lies in the range between 8% and 48%, of plaice (*Pleuronectes platessa* L.) between 4% and 26%, and of dab (*Limanda limanda* L.) between 7% and 15%. It should be noted that in addition to the effect of the pulse trawl, discard survival may also depend on seawater temperature, tow duration, time spent on the fish processing line, and possibly weather conditions and the state of the sea.

The issue of unaccounted mortality has been partially addressed by research (ICES, 2016). Studies carried out have demonstrated that the strength of the pulse stimulus experienced in non-uniform electric fields by an animal in the path of the trawl is dependent on the position of that animal relative to the electrodes. The research reported by ICES Working Group on Electrical Trawling (WGELECTRA) carried out by de Haan *et al.* (2016) shows that the field strength outside the path of the trawl is weak and therefore the effects of the pulse are local. It is therefore reasonable to assume that there is a low risk of large-scale unaccounted mortality of fish outside of the trawl.

No studies have to date been done on the long-term or cumulative effects of pulse trawling.

4. ICES recommends that a research programme should be set up to address outstanding issues, including long-term and/or cumulative effects of flatfish and shrimp pulse trawling.

   ICES notes that undertaking experiments on every species encountered by pulse trawls is not practically feasable. An approach based on indicators may offer a pragmatic way forward. This will require further work to identify indicator species and to develop guidelines in the use of these species in environmental impact assessments of pulse trawling.

ICES also notes that a four-year scientific research programme has recently been commissioned by the Dutch government. The programme addresses 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, and polychaetes) to the exposure by a range of pulse parameters representative for the commercial pulse trawls?; (2) Benthic ecosystem: what are the short- and long-termeffects of pulse trawling on the functioning and biogeochemistry of benthic ecosystems?; (3) Seabed: what is the effect of pulse trawling on 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? And (4) Synthesis: how does the transition of the tickler chain beam trawl fleet to a pulse trawl fleet affect the bycatch of undersized fish and what are the adverse effects on the benthic ecosystem? (Rijnsdorp *et al.*, 2015).

5. ICES advises not to generalize from the results of the research carried out to date to allow expansion of the use of the pulse trawl outside the present area and the fisheries allowed for in the current legislation. Extending the use of similar technology in other fisheries without a comprehensive environmental impact assessment would not be consistent with the precautionary approach. ICES considers that opportunities to trial fishing by electrical means in other fisheries should be made available in a structured, incremental way to allow for such impact assessments.

   Information on the impact of pulse trawling is based on current technology used in the flatfish and shrimp fisheries, and may therefore not be representative of the potential impact of pulse trawls in other fisheries or if significant changes are made to the current pulse trawl technology. Extending the use of current technology in other fisheries, or using new technology without a comprehensive impact assessment of the likely environmental impacts, would not be consistent with the precautionary approach.

6. The risk of negative impacts on species and habitats covered by the Natura 2000 directives is considered low in the current pulse characteristics.

   In relation to the impacts of the pulse trawl on habitats and sensitive (mostly non-commercial) species covered by the Habitats Directive, no specific studies have been conducted. Therefore, in the absence of quantitative observations, WGELECTRA carried out an assessment based on a qualitative evaluation of the potential impacts of pulse trawls on individual species in Natura 2000 sites/listings. With no information on the species concerned, the assessment of the potential adverse effects used information for species with similar morphological characteristics as proxies. For many species, it is not practically possible to obtain definitive advice. As the role of specific pulse characteristics have not been tested in a fully systematic manner and current legislation may not cover all the aspects necessary, it is not possible to ascertain whether the systems used can be adjusted to exceed thresholds that may result in a negative impact.

   The results of the qualitative assessment of effects on Natura 2000 species by the experts in the ICES WGELECTRA group (Table 1.6.7.1.1) suggest that the risk of negative impacts is low, as in reality the likelihood that any of the species listed would come into contact with a pulse trawl is low. Salmon is the only species listed for which research (not using the flatfish or shrimp pulse characteristics) has shown that susceptibility to spinal injuries exists under the influence of electrical pulses (Soetaert, 2015). The impact on the species is, however, considered low as current pulse fisheries do not take place in areas frequented by salmon and the bottom trawls used are not particularly suitable for catching salmon.

   The qualitative assessment of the impacts of the pulse trawl (flatfish and shrimp) on Natura 2000 habitats (Table 1.6.7.1.2) provides a reasonable basis for follow-up research into the physical impacts of a pulse trawl on those habitats that have a high likelihood of contact.

Table 1.6.7.1.1 Natura 2000 species. Qualitative evaluation of the risk of adverse impact of pulse trawl fishing on the species listed in the request. Likelihood of contact covers the probability of physical contact between the gear and the species. Potential adverse effect is the likely impact on the species following physical contact with the gear. Likelihood of adverse impact is the product of likelihood of contact and the potential adverse effect.

Species	Flatfish pulse trawl			Shrimp pulse trawl		
	Likelihood of contact	Potential adverse effect	Likelihood of adverse impact	Likelihood of contact	Potential of adverse effect	Likelihood of adverse impact
Petromyzon marinus (Sea lamprey)	low	low	low	moderate	very low	low
Lampetra planeri (Brook lamprey)	low	low	low	moderate	very low	low
Lampetra fluviatilis (River lamprey)	low	low	low	moderate	very low	low
Alosa alosa (Allis shad)	low	low	low	moderate	very low	low
Alosa fallax (Twaite shad)	low	low	low	moderate	very low	low
Salmo salar (Atlantic salmon)	low	low	low	low	very low	low
Tursiops truncatus (Bottlenose dolphin)	zero	unknown	zero	zero	unknown	zero
Phocoena phocoena (Harbour porpoise)	zero	unknown	zero	zero	unknown	zero
Lutra lutra (Otter)	zero	unknown	zero	zero	unknown	zero
Halichoerus grypus (Grey seal)	very low	unknown	very low	very low	unknown	very low
Phoca vitulina (Common seal)	very low	unknown	very low	very low	unknown	very low

Table 1.6.7.1.2 Natura 2000 habitats. Qualitative evaluation of the risk of adverse impact of pulse trawl fishing on the habitats listed in the request. Likelihood of contact covers the probability of physical contact between the gear and the habitat. Potential adverse effect is the likely impact on the habitat following physical contact with the gear. Likelihood of adverse impact is the product of likelihood of contact and the potential adverse effect.

Habitat	Likelihood of contact	Potential adverse effect	Adverse physical impact relative to traditional gear	Comment
Flatfish pulse trawl				
Sandbanks which are slightly covered by seawater all the time	moderate	low	lower	
Estuaries	low	low	lower	
Mudflats and sandflats not covered by seawater at low tide	zero	low	lower	
Coastal lagoons	low	low	lower	
Large shallow inlets and bays	low	low	lower	
Reefs	moderate	low	similar for delicate reefs, lower for more sturdy reefs	
Submarine structures made by leaking gases	zero	zero	similar – lower	physical structures
Shrimp pulse trawl				
Sandbanks which are slightly covered by seawater all the time	high	very low	similar – lower	
Estuaries	low	very low	similar – lower	
Mudflats and sandflats not covered by seawater at low tide	moderate	very low	similar – lower	
Coastal lagoons	moderate	very low	similar – lower	
Large shallow inlets and bays	zero	very low	similar – lower	
Reefs	moderate	very low	similar – lower	
Submarine structures made by leaking gases	zero	zero	similar – lower	

Basis of the advice

In 2012, on request from France, ICES provided advice on the ecosystem effects of pulse trawl, with focus on the amount of injury and mortality for target and non-target species that contact the gear but are not retained. WGELECTRA (ICES, 2016) provides an update and a synthesis of recent work undertaken in the area since 2012. The report of WGELECTRA was reviewed by an independent review group (RGPULSE). The current advice is based on the findings of WGELECTRA and RGPULSE, as well as advice and information presented in 2012.

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