Working Group on Electrical Trawling (WGELECTRA; outputs from 2021)

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Contents

i Executive summary

The Working Group of Electrical Trawling creates a platform for supra-national joint research projects on electro-trawling and scientific publications. The group also reviews all relevant studies on marine electrofishing and discusses the ongoing and upcoming research projects in the light of knowledge gaps.

Research areas covered by the group included fishing tactics and dynamics, organisms and ecological impacts and selectivity of electro trawling. A study into the exploitation of local fishing grounds revealed that pulse trawlers and conventional tickler chain beam trawlers had similar tactics spending 10% of their tows searching for a fishing ground and spending 90% of their tows exploiting a fishing ground. In-situ field campaigns revealed a lower impact of pulse trawls on biogeochemical parameters compared to traditional beam trawl methods. Laboratory experiments found that while alternating or pulsed bipolar currents readily penetrated the sediment, biogeochemical effects appeared to be inhibited from occurring. The combined results concluded that the environmental impact of electricity from pulse trawls is relatively minor compared to the mechanical disturbances created from the same gears. Behavioral response thresholds for pulsed electric fields were determined in laboratory experiments for electro-receptive as well as non-electroreceptive fish species. Comparison of these thresholds to simulations of electric fields around commercial fishing gears suggest that electrical pulses are unlikely to substantially affect the investigated fish species outside the trawl track. A field study into direct mortality among fish and benthic organisms in the wake of pulse trawlers refuted claims that pulse trawling causes mass mortality among non-target species. A study into the selectivity of shrimp pulse trawling vs. traditional trawling concluded that that shrimp fishing using pulse gear does not result in higher amounts of undesired bycatches of small shrimp, fish and benthos when compared to the traditional shrimp beamtrawl fisheries. The outline of a PhD project that started in 2021 into organism and ecological impacts of electrofishing for razor clams in Scottish shallow coastal habitats was presented and preliminary results were shared.

ii Expert group information

Expert group name	Working Group on Electrical Trawling (WGELECTRA)
Expert group cycle	Multiannual fixed term
Year cycle started	2021
Reporting year in cycle	1/3
Chair(s)	Mattias van Opstal, Belgium
	Edward Schram, The Netherlands
Meeting venue(s) and dates	9-10 November, online teams meeting (13 participants)
	TBD
	TBD

1 Introduction

Investigations to use electricity in catching target species have a long history (Soetaert et al., 2015b). In the North Sea, the studies focused on the fishery for sole, *Solea solea*, and brown shrimp *Crangon crangon* (Boonstra and de Groot, 1970; Vanden Broucke, 1973). The early studies were successful and indicated an improved catch efficiency for sole and a reduced bycatch of undersized fish (van Marlen et al., 2014). For the bottom trawl fishery for shrimps Polet et al. (2005) showed that electrical stimulation could considerably reduce the bycatch of both fish and undersized shrimps. In 1988, the EU decided to include the electrified fishing in the list of illegal fishing methods on the basis that allowing an even more efficient fishing gear in the fishery for North Sea sole, could aggravate the over-capacity of the fleet and could overfishing.

Around 2005, there was renewed interest in applying the pulse trawls in the beam trawl fisheries targeting sole *Solea solea* and plaice *Pleuronectes platessa* (van Balsfoort et al., 2006). The low TAC in combination with a high fuel price jeopardized the economic viability of the fleet while the growing concern about the disturbance of the seabed and the benthic ecosystem and the high discard rate, called the fishery to improve its practices. In 2006, the EU allowed North Sea member states to issue pulse trawl licenses to up to 5% of their fleet. In 2011 and 2014, the Netherlands got permission from the EU to issue 20 and 42 additional licenses up to a total of 84 (Haasnoot et al., 2016).

The use of electricity to catch sole raised concerns about the possible increase mortality on target and non-target species, including those that are not retained in the gear, about a possible increase in the fishing mortality of sole and plaice, and on delayed mortality, long term population effects, and sublethal and reproductive effects on target and not-target species (ICES 2006, 2012, 2016). ICES (2012, 2016) recognized that conventional beam trawling has significant and well demonstrated negative ecosystem impacts, and if properly understood and adequately controlled, electric pulse stimulation may offer a less ecologically damaging alternative. ICES (2016) therefore advised to undertake structured experiments that can identify the key pulse characteristics and thresholds below which there is no evidence of significant long term negative affect marine organisms and benthic communities. ICES (2016) also recommended 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. ICES (2016) recommended 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. Following the request from the Netherlands to "Analyse the possible contribution of pulse trawling to reduce or increase the ecosystem/environmental impacts of the fishery for sole in the North Sea and reflect on the fuel consumption used in the fishery sole in the North Sea" the working group reviewed the available information to provide the science base for an advice (ICES, 2020).

The current report presents the results of research into pulse fisheries for sole, brown shrimp and razor claims conducted or completed in since 2020. The future of the working group in light of the current pulse trawling ban and the subsequent decline in the number studies into pulse fisheries was discussed.

2 Sole pulse

2.1 A comparison of the tactics of pulse trawl and conventional tickler chain fishers to exploit local fishing grounds – Adriaan Rijnsdorp

The fishing tactics and dynamics of the exploitation of local fishing grounds was studied for the pulse trawl (PT) and compared to the conventional tickler chain beam trawl (BT) from monitoring datasets where fishers recorded the time and position of hauling and shooting their gear and the corresponding catch weight of the main flatfish species, as well as automated position recordings at 1 min and 6 min intervals of PT and BT, respectively. Fishing grounds were defined by hierarchical clustering of fishing positions of each tow using a distance criterion of h=3 nautical miles (nm). The methodology allowed the estimation of variable shaped polygons representing fishing grounds of tow aggregations. The surface area of a fishing ground was estimated at 250 km2 (PT) and 297 km2 (BT). PT systematically trawled a fishing ground by placing their tows parallel with each other at a short distance, or by folding the tow tracks in parallel segments. The size of the core of the fishing grounds, comprising tows clustered at h=0.5nm, was estimated at 24 km2 (PT) and 34 km2 (BT). The catch rate in the core of the fishing grounds was about 50% higher than the back-ground catch rate. PT and BT beam trawlers had similar tactics spending 10% of their tows searching for a fishing ground and spending 90% of their tows exploiting a fishing ground. The median time between the start of the first and the end of the last towon a fishing ground was estimated at 1.5 days. The probability to fish in the core of the fishing ground increased during the exploitation event and decreased again at the end. The catch rate obtained in the core of the fishing ground declined with time and was proportional to the rate at which the surface area of the core was swept in PT but was substantially higher in BT. The difference is likely due to the stronger avoidance response of flatfish to the BT gear than to the PT gear.

2.2 Pulse trawl effects on benthic ecosystem functioning – Justin Tiano

Electric pulse trawls are linked with reduced discards, fuel use, and bottom disturbance compared with conventional beam trawls rigged with tickler chains, however, major concerns have presided over the impact of electricity on marine ecosystems. This presentation details several studies exploring the effects of electric pulse trawling on benthic ecosystems. In-situ field campaigns revealed a significant but lower impact of pulse trawls on biogeochemical parameters compared with traditional beam trawl methods, though effects on macrofaunal abundances showed variable results. Controlled laboratory experiments found that while electricity readily penetrated the sediment, it only induced biogeochemical changes when high frequency pulsed direct currents were used and only if for a prolonged (2 min) period of time. Alternating or pulsed bipolar currents appeared to inhibit biogeochemical effects from occurring. Furthermore, only short term and non-lethal effects were observed on benthic macrofaunal behaviour. The combined results of this research conclude that the environmental impact of electricity from pulse trawls is relatively minor compared to the mechanical disturbances created from the same gears. Mechanical disturbance from pulse trawling can lead to significant consequences for benthic ecosystems, however, their overall environmental impact compared to tickler chain beam trawls is reduced.

2.3 Behavioural response thresholds of marine fishes for pulsed electric fields – Boute, P.G., van Leeuwen, J.L., Lankheet, M.J.

Electrical pulse trawling is an alternative to conventional beam trawling for common sole (*Solea solea*), with substantially less discards, lower fuel consumption, and reduced affect the benthic ecosystem. Pulsed electric fields between electrode arrays induce a muscle cramp, immobilizing the fishes on the seabed, making them easier to catch. Concerns exist, however, that the electric fields extend well beyond the netting, potentially affecting fishes outside the trawl track. Here, we address these concerns by measuring amplitude thresholds for behavioural responses and compare these response thresholds to the field strengths around the fishing gear. Electroreceptive small-spotted catshark (*Scyliorhinus canicula*) and thornback ray (*Raja clavata*) as well as non-electroreceptive European sea bass (*Dicentrarchus labrax*), turbot (*Scophthalmus maximus*), and common sole were, one at the time, placed in a ⌀2.5 m circular tank with seven, individually controlled, evenly spaced electrode pairs, spanning the tank's diameter. Behavioural responses were assessed from camera recordings for different pulse amplitudes and for different positions of the fish relative to the stimulating electrodes. Computer simulations of the electric field, verified with measurements in the experimental setup, were subsequently used to determine the electric field strength at the animal's location for each stimulus. Preliminary results show that behavioural response thresholds were not substantially lower in electroreceptive fish than in non-electroreceptive fish. A comparison of threshold field strengths to simulations of electric fields around commercial fishing gears showed that behavioural responses are limited to distances less than 1 metre from the fishing gear. These findings suggest that electrical pulses as used in pulse trawling are unlikely to substantially affect the investigated fish species outside the trawl track.

2.4 Direct mortality among demersal fish and benthic organisms in the wake of pulse trawling – Edward Schram, Pieke Molenaar, Susan de Koning, Adriaan Rijnsdorp

Pulse trawl fisheries involve the use of electrical pulses to immobilize (cramp) target species and make them available for capture. A major concern related to pulse trawl fisheries is the passing pulse trawl causing direct, mass mortalities among benthic organisms, resulting in a 'graveyard' in the wake of a pulse trawler. Until 2019 this had never been investigated *in situ*. In 2019 a pilot study developed a method for *in situ* assessments and collected the first data on direct mortality among fish and benthic invertebrates. More data using the same methodology were collected in a second experiment in 2020. The data collected in 2019 and 2020 were merged into one dataset. We here report on the combined dataset.

Two pulse trawlers equipped with double rigs made pulse trawl tracks for the purpose of the current experiments. Within 15 to 30 minutes after passage of a pulse trawler, one of its trawl tracks was sampled with a shrimp trawler by a 10-minute tow with a small mesh shrimp beam trawl while the other, similar shrimp trawl was deployed outside the pulse trawl track to obtain control samples. Experiment 1 (2019) consisted of two pulse trawl track treatments: a complete pulse trawl and a pulse trawl with its netting and ground rope removed to minimize its mechanical impact. This allowed for isolating electrical from mechanical impacts. In total two paired samples of treatments and controls were obtained per pulse trawl track treatment. In experiment

1 there was no difference in direct mortalities among biota sampled from the two pulse trawl treatments, therefore in Experiment 2 only the complete pulse trawl treatment was employed.

The condition of three fish species and four species of invertebrates was assessed. Fish species included plaice (*Pleuronectes platessa*), dab (*Limanda limanda*) and solenette (*Buglossidium luteum*). Invertebrate species included flying crab (*Liocarcinus holsatus*), hermit crabs (*Paguroidea spp.*) brittle stars (*Ophiuroidea spp.*) and brown shrimp (*Crangon crangon*). Underwater video observations confirmed deployment of the sampling trawl inside the pulse trawl tracks, although part of the swept-area was outside the pulse trawl tracks and data were corrected for this. Direct mortality was low and ranged from 0-10% among treatments for the fish and 0-16% for the invertebrates.

Our study did not find any evidence of direct mortality nor deteriorated condition among plaice, dab, solenette, flying crab and brittle stars as a result of a passing pulse trawler.

Throughout the study period (2019-2020), we have conducted workshops and interviews with Dutch small-scale fishers and representatives. The workshops and interviews were aimed at understanding the general perception of pulse fisheries and the specific concerns of small-scale fishers with regard to pulse fisheries. Our results show that after the pulse was banned and the first fieldwork in 2019 had been completed, worries of small-scale fishers shifted from mass mortality among benthic organisms towards alleged misuse of pulse gear resulting in (local) overfishing and displacement of other types of fisheries. The interviews and workshops gave valuable input into study design, resulting in a change of location for experiment 2, as small-scale fishers attach great importance to the location of the fieldwork.

3 Brown shrimp pulse

3.1 Selectivity of shrimp pulse trawling vs. traditional shrimp beam trawling - Results of a baseline and innovation study – Mattias Van Opstal and Josien Steenbergen

In the Southern North Sea, fishermen have been trawling for brown shrimp (*Crangon crangon*) since the first half of the 20th century using beam trawls with bobbins. In the last decades fishermen are challenged to fish more efficiently and there is a need to reduce bycatch and discard rates. A proposed solution is the use of pulse gear. In earlier studies the use of pulse gear has already proven to reduce bycatch and discard rates. Nevertheless, for the new pulse gear to be allowed to be used commercially in the Natura2000 areas in the Netherlands, where most of the shrimp fishing takes place, more information on the performance of the gear is required. The aims of the current study are 1) to investigate the difference in selectivity of pulse and traditional gears in a baseline study and 2) to contribute to further development and innovation of the current pulse gears.

As most of the Dutch shrimp fisheries takes place in designated Natura2000 areas its is important to know if a new technique like the pulse gear does *at least* not bring more harm to the environment than the standard traditional gear. For that reason the leading question of the baseline study was whether or not shrimp fishing using pulse gear resulted in higher amounts of bycatches of small "non-commercial" shrimp (< 50 mm), fish and benthos when compared to traditional shrimp fisheries, and if these possible differences are affected by the location of the fisheries and the time of the year. In order to answer this question data were collected on board of commercial shrimp vessels. The fishermen of these vessels, equipped with either pulse gear or traditional gear, recorded their catches and landings year-round. Additionally, to these 'self-recording' trials, 'gear trials' were undertaken on vessels equipped with on one side pulse gear and on the other side traditional gear. During these "comparative trials" ('gear trials') detailed information on the composition of the catches and amounts of individuals of bycatch species caught was collected and analysed by researchers from ILVO and WMR.

The overall conclusion of the study is that shrimp fishing using pulse gear does not result in higher amounts of undesired bycatches of small shrimp, fish and benthos when compared to the traditional shrimp beamtrawl fisheries. In more detail; the weigth of small shrimps in the catch relative to the commercial shrimps was the same for pulse gear and traditional gear. The weight of undesired bycatch of other species in relation to the total shrimp weight, on the contrary, was higher for the traditional gear than for pulse gear. Based on the comparative studies it seemed there was no significant difference in selectivity for both gears for the majority of species. Although there were some expeptions based on seasonal difference and differences between areas for certain species. The pulse gear was significantly more selective for catches of the flatfish species plaice and flounder in all areas, dab the North Sea Coastal zone and the Voordelta and for sole in the Wadden Sea and the North Sea Coastal zone. Meaning that more indivuduals of these species were found in traditional gears. The pulsetrawl was also *significantly* more selective for the round-fish species bullrout, hooknose, viviparous blenny and bib (only in the Wadden Sea). Sandeels on the other hand were in some cases significantly more abundant in the pulse trawl nets, just as the Clupea species in the first quarter of the year (Q1) and five-bearded rockling in the Voordelta and the flatfish species scald fish in the North Sea Coastal zone (contrasting catches in other areas). These seasonal and local differences can probably be explained by differences in abundance of the species in different areas/seasons; the more a species is abundant, the more likely it is that a significant difference in is statistically detected.

As a next step of the study a workshop was organized with the involved fishermen, scientists from WMR, ILVO and Thünen Institute a representative of the ministry (Ministry of Agriculture, Nature and Food Quality) and natuurmonumenten (NGO). During the workshop, innovations were proposed that might improve the efficiency of pulse gear, especially during cold months as these are months when pulse gear has lower catch rates than traditional gear. Five innovations resulted from the workshop. These were subsequently tested on three fishing vessels and compared with the "traditional" pulse gear. The length of the electrodes and distance to the bobbin was changed, pulse settings were altered, discs were added between the bobbins, a sieve mat instead of a sieve net was put in place, and a replacement of the bobbins with discs were the tested innovations. The electrodes, the pulse settings, and sieve mat did not prove to be efficient or useful innovations compared to the "traditional" pulse. Adding discs to the bobbin rope of a pulse gear led to an increase in the catch of commercial cooked shrimp by 3% while reducing bycatch and discard volume by 9% and 14% respectively, compared to a traditional trawl with 36 bobbins on a round bobbin rope. The replacement of bobbins by discs, resulted in a 5% decrease in catch, this was accompanied by an approximate reduction of 11,5% and 24% in bycatch and discard volume compared to the "traditional" pulse. This relatively cheap solution can help fishermen catch enough shrimp in colder water and have a lower affect the ecosystem.

4 Electric fishing for razor clams

4.1 Organism and ecological impacts of electrofishing for razor clams in Scottish shallow coastal habitats – Chloe Blackman

Razor clams (Ensis sp.) have been collected for millenia at a low level for local consumption but commercial landings began to increase in the late 1990s. Clams begun to be collected using mainly hydraulic dredges from beds in Ireland and Scotland. At the time the main market was in Iberia, but this declined in the early 2000s but was replaced by new markets in the Far East. Reports that illegal electrofishing was taking place in Scotland began to emerge in the press with reports of high profits from the Far Eastern sales. In this approach, exposure to an electric field causes the razor clams to emerge from the sediment so that they can be collected by divers following behind the electrofishing rig. Because fishing with electricity is illegal under the Common Fisheries Policy these activities were of concern to the Scottish Government. In 2016, the Scottish Government consulted on whether electrofishing should become a permitted method for harvesting razor clams. Following this consultation, it was announced that controlled commercial research trials, which are permitted under the CFP, would commence in February 2018. The aims of these trials are to restrict the fishing activity to a controlled number of licenced vessels, to tightly control the electrofishing gear being deployed by the vessels, to control the spatial areas where electrofishing takes place, to gather further information about the impacts of electrofishing and to evaluate the potential for such fisheries to be managed within sustainable limits. It is important to realize that the electrofishing technique used in razor clam harvesting is different from that in the pulse-trawls used in the southern North Sea sole fishery.

A PhD project into organism and ecological impacts of electrofishing for razor clams in Scottish shallow coastal habitats started in 2021. The outline of this PhD project was presented during WGELECTRA 2021.

5 History and future, lessons learned from a social science perspective – Hans Polet, Pim Visser and Marloes Kraan

Hans Polet provided historic context by presenting and extensive overview of the history of pulse fisheries covering the period from 1765 till today.

Social scientist Marloes Kraan presented the lessons learned from a social science perspective, in which she looked both back and forward in time. She discussed in detail her (and her co-authors', Kraan et al., 2020) response to the scientific paper by Bloom (Le Manach et al., 2019). The Bloom paper claims that electric trawling has a substantive negative impact, was supported by illegal subsidies and that in the process the Dutch government and industry were not transparent. Kraan et al., (2020) respond by claiming that claims in Le Manach et al., (2019) are misleading and, in some instances, demonstrably false. Kraan et al., (2020) also reflect on the role of advocacy science in the governance of fishing gear innovation in the EU and concludes that the role of science in political decision can be damaged by the misrepresentation of scientific data and assuming a position of false neutrality and objectivity by NGOs engaging in science-advocacy.

Based on the lessons learned from pulse fishing Kraan proposes the use of "Regional innovation councils" for future fisheries innovations. These councils should ensure essential transdisciplinary collaborative research by institutions and actors that allow multiple levels of collaboration, resulting in innovations that are not only technically but also politically sound and socially acceptable.

Pim Visser, former director of VisNed, a Dutch fishers organization, started with the disclaimer that in his presentation contains his personal opinions and views and by no means those of VisNed or its members. Visser addresses the question why the pulse development ended up in a debacle by applying issue management and analysis theory. Visser recommends not to publicly discuss pulse trawling for at least 2-3 years as the topic is 'toxic', while continue the research with a focus on brown shrimp fisheries with the involvement of politics, EU member states and NGOs. He also recommends that the ban on bottom trawling rather than the ban on pulse trawling should be dealt with first, a plan of approach for innovative gears should be developed, to consider any and all thinkable and unthinkable questions, to look actively for involvement, to be completely open and fully transparent and to make yourself and your innovation vulnerable. He poses the question who should take initiative to start this process.

6 Varia

6.1 Discussion on the future of the working group

The group discussed the future of the working group in light of the pulse trawling ban and subsequent decline of the number of research projects into pulse fisheries. It was observed that the only current and ongoing research project is the research into electrofishing for razor clams by Chloe Blackman. A broader scope of the working group, i.e. inclusion of other gear or trawling innovations and other impacts of electricity on marine life (e.g. electric cables in/on the seabed for wind farms), was discussed with the conclusion that these topics are already covered by other ICES Working Groups. The group members expressed their interest attending the working group in 2022, provided sufficient new research results are available by that time to compile an attractive program. It was therefore decided that a final decision on the organization of a 2022 event will be based on an inventory among the members (by the chairs) of new material to fill a program.

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Annex 1: List of participants

2021 Participants

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Annex 2: Resolutions

WGELECTRA - Working Group on Electrical Trawling

2020/FT/EOSG07 A **Working Group on Electrical Trawling (WGELECTRA),** chaired by Mattias van Opstal, Belgium, and Edward Schram, the Netherlands, will work on ToRs and generate deliverables as listed in the Table below

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2021	9-10 November 2021	Online Meeting	Interim report by 31 of December 2021 to ACOM-SCICOM	
Year 2022	TBD	TBD	Interim report by 31 of December 2022 to ACOM-SCICOM	
Year 2023	TBD	TBD	Interim report by 31 of December 2023 to ACOM-SCICOM	

ToR descriptors1

ToR	Description	Background	Science Plan Codes	Duration	Expected Deliverables
a	Produce a state-of-the-art review of all relevant studies on marine electrofishing. Yearly update it by evaluating and incorporating new research to it.	a) Science Requirements b) Advisory Requirements	2.1, 6.1, 6.4	Yearly update	Review report
b	Discuss and prioritize knowledge gaps, and discuss ongoing and upcoming research projects in the light of these knowledge gaps, including the experimental set up	a) Science Requirements b) Advisory Requirements	2.1, 2.7, 6.4, 6.6	Year 1, 2 and 3	Scientific research adressing knowledge gaps or questions from management
c	Create a platform for the application for supra-national joint research projects on electrotrawling and scientific publication of the obtained results	a) Science Requirements b) Advisory Requirements	3.1, 6.6	Year 1, 2 and 3	Joint projects and publications among participants and others Collaboration with other related WG's such as WGNSSK, WGCRAN

[1] Avoid generic terms such as “Discuss” or “Consider”. Aim at drafting specific and clear ToR, the delivery of which can be assessed

d	Discuss and synthetize new and emerging techniques and technologies that have potential to become alternatives for Electrical Trawling	a) Science Requirements b) Advisory Requirements	2.1, 2.7, 4.1, 4.5	Year 1, 2 and 3	Joint projects and publications among participants and others Collaboration with other related WG's such as WGFTFB
e	Discuss future for electrical trawling and the lessons learned when deploying new technologies.	a) Science Requirements b) Advisory Requirements	2.7	Year 1, 2 and 3	Joint projects and publications among participants and others Collaboration with other related WG's such as WGFTFB

Summary of the Work Plan

Year 1	**- Discussing and evaluating ongoing and recently completed research** **- Evaluating and presenting results from research projects - Answering possible requests**
Year 2	- Updating the review document - Discussing and evaluating ongoing and recently completed research - Evaluating and presenting results from joint research projects - Answering possible requests
Year 3	- Finalize the review document - Discussing and evaluating ongoing and recently completed research - Evaluating and presenting results from joint research projects - Answering possible requests

Supporting information

Priority	**The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.**
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other committees or groups	There is a very close working relationship with all the groups XXXSG. It is also very relevant to the Working Group on XXX.
Linkages to other organizations	