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Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB)

31 May - 4 June 2010

ICES Headquarters, Copenhagen

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) met in Copenhagen, Denmark from 31 May – 4 June 2010 to address five Terms of Reference. The main outcomes related to the ToRs are detailed below.

Key Findings

Advice to Assessment Working Groups (Section 13)

- All countries have reported very low prices for fish and shellfish and there are indications that prices for some species have dropped by as much as 50% on 2007 levels. In the case of EU countries imports from third countries and the world recession are the main reasons given.
- Fuel prices have stabilized to some degree although in many countries, fuel is still a driving factor in their operational decision-making. In a number of countries effort e.g. Norwegian shrimp fisheries have declined in some fisheries due directly to fuel costs. In other countries fleets have altered their operational strategies to minimize fuel costs but also to access markets optimally.
- As in 2009 the new EU Cod Recovery Plan covering a number of areas including the North Sea, West of Scotland, Irish Sea, Baltic Sea and Skagerrak/Kattegat as well as technical measures introduced into ICES Area VIa (West of Scotland) are still creating difficulties for fleets in a number of countries. There has been a continuation in the reported shifts in effort from areas without effort or less restricted by effort caps, from areas where the kw days allocated to vessels are felt inadequate.
- There continues to be a move in France and Netherlands to convert to Danish seining instead of conventional trawling or beam trawling. These vessels are quite high powered compared to traditional seine net vessels and are using this power as well as sophisticate deck machinery to increase overall fishing time. A number of vessels entering this sector are being rigged as dual purpose vessels to take advantage of both seining and trawling opportunities.
- There has been a large shift in the Irish fleet into on-board freezing of *Nephrops.* Approximately 22 vessels are now rigged for on-board freezing. This is mainly motivated by strong markets for frozen *Nephrops* as the traditional fresh markets for whole and tailed *Nephrops* still seems to be over supplied.
- Decommissioning schemes are less in evidence with most Member States having suspended such schemes for the foreseeable future. Varying amounts of effort seemed to have been removed from the fleets involved but as reported last year there are indications in several countries that some of this effort is being reintroduced into fleets through purchasing of dormant licences. The impact of decommissioning therefore may not be as high as perhaps anticipated in terms of overall effort reductions. There is also some evidence of fleet renewal, particularly in the Scottish *Nephrops* fleet.
- The effects of technological creep are still evident in many fisheries as observed in 2006, 2007, 2008 and 2009 with the main focus on fuel efficiency

measures. In Norway there have been continuing attempts to use pelagic gears for targeting demersal species such as saithe and cod, while in several countries there has been experimentation in demersal fisheries with trawl doors that fish "off-bottom". This is mainly driven by reducing fuel consumption but potentially has added environmental impact advantages over traditional trawl doors.

- In the Netherlands and Belgium there has been high uptake of new fuel efficient beam trawl designs (e.g. SumWing), which have been extensively tested and shown to be give fuel savings as well as increased fishing time.
- As in previous years there have been a number of developments in gear design to reduce drag including the use of low drag netting in both pelagic and demersal fisheries. In Italy there has been adoption of twin-rigging instead of traditional single-rig trawls. This particular move has created concern among the Italian authorities given the improved efficiency of this method. There is also increased use of 3D mapping sonar systems in a number of countries (UK, France, Belgium, Netherlands) as fishers try to open up new areas.
- One particular issue that has arisen is the introduction of the OMEGA mesh gauge. The industries in a number of countries have reported problems with the implementation of this new mesh gauge. It is claimed that this gauge gives measurements of ~5%-10% less than the wedge gauge previously used by fisheries inspectors. The industry claims the introduction of this gauge is effectively an increase in mesh size and also that fishers have been forced to replace codends which prior to the new regulations were perfectly legal.
- In a number of fisheries as in previous years research into selective gears has been extensive but still with only limited uptake. The drivers for uptake are still clearly regulatory, i.e. as a means of attaining an increased quota entitlement or increased access; or economic through higher price paid for a responsibly caught product.
- The main ecosystem effect noted has been discarding in a variety of fisheries. Discarding of cod, haddock and hake in the West of Scotland and Celtic Sea are among the worst cases reported and discarding in this instance seems to be driven by quotas being very restrictive in Q3 and Q4 of 2009 as fishers strive to stay within regulations but also by low prices for smaller grade fish.
- On a more positive note improvements in stocks have been noted in several areas. In particular hake and megrim in the Celtic Sea and West of Scotland have been reported as being abundant.
- A number of gear modifications have been tested and in some cases are being used to reduce the bottom impact of towed gears. A number of initiatives have been introduced to the Dutch and Belgium beam trawl fleets to reduce the catch of benthos as reported in 2009 and these are being used on a voluntary basis in many cases.
- There are a few reports in 2010 of suspected bycatch of protected species including cetaceans, sea turtles and seabirds. Testing of acoustic deterrent devices is continuing in a number of fisheries. Predation by seals has been reported as continuing problems in Ireland in gillnet fisheries. This problem has been reported for a number of years and seems acute.

- Several new fisheries have been reported in 2010. Two are pelagic fisheries of which one is on an experimental basis in international waters and the other is a small-scale pelagic fishery for anchovy off the southwest coast of the UK. There is also continued experimentation of static gears as a means for targeting fish although the indications are that these fisheries are still not economically viable in most cases. There is one example of a dive fishery for scallop developed in France.

Assessment of Seine Net Fisheries (Section 14)

- An assessment of seine netting has been completed by WGFTFB and identified some positive and negative effects of this fishing method. From the assessment WGFTFB concluded that seine netting appears in many respects to still be an environmentally friendly fishing method. All of the information reviewed showed seining to be fuel efficient, with high catch quality and low environmental impact when compared to trawling. There are concerns though regarding discarding levels in some seine net fisheries.
- With respect to selectivity WGFTFB reviewed the methods used to measure the selectivity of seine nets. These methods were alternate hauls, covered codend and trouser seines. All of these measures have their problems mainly relating to variability between hauls. This seems to be a particular problem with seine net gear.
- WGFTFB have reviewed the most recent selectivity experiments carried out globally with seine net gear. A number of different selectivity devices have been tested to improve seine net selectivity in addition to simple increases in mesh size. These include the use of square mesh panels, square mesh codends, separator panels, coverless trawls with reduced top sheets and footrope modifications. The results from these studies are varied and all of them indicated that while there appeared to be ways of improving selectivity, in practice it is difficult to obtain definitive results.
- Although the process of fish capture in a seine is quite different from a trawl, selectivity experiments do not indicate higher selectivity or lower discard rates for seines compared to trawls of the same codend mesh size.
- With respect to square mesh codends research in Canada, Norway and the UK has shown they retain more small flatfish but less small gadoids when compared to diamond mesh of the same size. Thus they seem applicable in gadoid fisheries provided appropriate materials can be found.
- Square mesh panels seem to improve the selectivity of seines although the optimum position for the panel still needs to be resolved.
- Other devices such as sorting grids and separating panels have been shown to be reasonably effective but the research in Norway suggests that at least with respect to grids that changes to mesh size and shape are more applicable to seine nets. The more novel gear modifications tested such as the "topless" seine and modifications to the footrope look encouraging but there is not enough data to make any firm conclusions.
- The limited Scottish data available for pair seines suggests that there are differences in selectivity of this gear compared to demersal trawls and single boat seines but this is poorly understood.

- WGFTFB also noted some elements of technological creep to be potentially negative, in particular the move in the North Sea towards pair seining as opposed to single boat seining and also to tow-dragging in deeper waters in a number of countries. These adaptations to seining are considered to be more akin to traditional trawling and potentially may increase the benthic impact in these fisheries. WGFTFB felt therefore that there is a need to carefully consider whether these gears are actually "seines" in the true sense when framing legislation which differentiates between seines and trawl gear.
- WGFTFB also considered the use of heavier seine rope and heavier groundgears in some seine net fisheries but could not make any firm conclusions whether these significantly increased impact. The development of better deck machinery and gear monitoring equipment was felt by the group potentially to increase fishing efficiency but also to improve safety on-board seine vessels and so has positive and potentially negative effects.

Gear Monitoring Systems (Section 15)

- Scientific use of net mensuration and other sensor systems requires more communication and understanding between manufacturers and system users than commercial use.
- Systems include different capabilities, and limitations, that should be understood by users before and after purchase.
- Sensor systems require continued maintenance and technical support post-purchase
- Knowledge of sensor accuracy was generally emphasized by WGFTFB.
- Accurate calibration of net sensors is necessary for scientific rigor.
- Communication between scientists and manufacturers in this forum has been instructive and helpful.
- A continuing need for additional measurement of trawl functions and gear modifications requiring additional sensor development was found.

Innovation in Fishing Gear Technology (Section 16)

- Innovation is definitely needed for fishing industry to survive.
- Innovation needs strong motivation and clear objectives. Incentives are generally related to finding ways to continue fishing, e.g. access to grounds closed without taking measurements, more days at sea, better economy, e.g. lower costs (fuel).
- Results should be practical, meet the objectives and work well on a fishing boat under commercial conditions, without incurring great losses in income for fishers.
- Mutual trust and respect of project participants are vital for success. Open and effective communication is needed.
- Ample finance should be given, projects at sea are expensive, and results not expected in a few months. At least a time span of several years will be needed.
- A proper working methodology enables good results and facilitating fishers being engaged in research activities is necessary.

WGECO/WGFTFB Framework for analysis of GBTMs (Section 17)

- On the basis of the three case studies considered, WGFTFB conclude that the methodology developed is unduly complex and data demanding to be applicable for assessing GBTMs. In addition it is further concluded that the use of Significant Adverse Impact is not an appropriate metric as in reality data deficiencies make it extremely difficult to show any GBTM, even extensively studied ones would reduce SAI to any degree.
- Despite these major limitations, WGFTFB concludes that the methodology could be adapted to assess GBTM's developed to reduce benthic impacts. Such gear measures impact on a number of ecosystem components and in such studies, researchers routinely collect information on a wide range of species as well as looking at habitat impact.
- WGFTFB recommend that gear technologists carrying out research with gear measures designed to reduce bycatch and/or discarding should be encouraged to collect information on as many species (both commercial and non-commercial) as possible to allow more information and ultimate analysis of whether such GBTM can deliver positive benefits for the stocks of these species.
- WGFTFB conclude that the protocol used in the UK study to evaluate the legislation put into force for the *C. crangon* fisheries is both holistic and effective. The same protocol can potentially be used elsewhere in other fisheries to conduct similar evaluations on the efficacy of technical measures. This protocol includes an evaluation of the legislation text, performance of the gear modifications, including environmental effects and a socio-economic evaluation

1 Directive

The directive of the WGFTFB is to initiate and review investigations of scientists and technologists concerned with all aspects of the design, planning and testing of fishing gears used in abundance estimation, selective fishing gears for bycatch and discard reduction; as well as benign environmentally fishing gears and methods with reduced impact on the seabed and other non-target ecosystem components.

The Working Group's activities shall focus on all measurements and observations pertaining to both scientific and commercial fishing gears, design and statistical methods and operations including benthic impacts, vessels and behaviour of fish in relation to fishing operations. The Working Group shall provide advice on application of these techniques to aquatic ecologists, assessment biologists, fishery managers and industry.

2 Introduction

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Venue: Copenhagen, Denmark

Date: 31 May – 4 June 2010

3 Terms of Reference

The **ICES-FAO Working Group on Fishing Technology and Fish Behaviour** (WGFTFB), chaired by Dominic Rihan, Ireland, met at ICES HQ, Denmark, 31 May – 4 June 2010 to:

Terms of Reference

a) Incorporation of Fishing Technology Issues/Expertise into Management Advice based on the questionnaire exercise carried out since 2005/2006.

Conveners: Dominic Rihan (BIM, Ireland)

b) A WGFTFB topic group of experts formed in 2009 will meet in 2010 to continue to address the following ToRs:

   i) Identify all seine net fisheries globally and describe the gears being used in terms of net design, rope material and construction, as well as areas being worked.

   ii) Critically assess these fisheries, identifying the positive aspects in terms of reduced fuel consumption, high fish quality and low bottom impact as well as the negative aspects with respect to gear selectivity and technological creep.

   iii) Evaluate methods for determining selectivity in these gears to allow comparison with conventional towed gears e.g. otter trawls

   iv) Make recommendation for research/monitoring work to substantiate (or otherwise) claims for environmental friendliness, discarding, unaccounted fishing mortality.

   Conveners: Harldur Einarsson (MRI, Iceland) and Paul Winger (MI, Canada)

c) A WGFTFB topic group of experts will be formed in 2010 with the following terms of reference:

   i) Compile an inventory of current gear monitoring systems including remote data collection devices that can be mounted on gear (pitch and roll sensors)

   ii) Assess these systems based on experiences and identify problems associated with each system both for gear research and survey. This will be carried out in discussion with manufacturers.

   iii) Gather and review data collection software both manufacturers and purpose built software.

   iv) Recommend improvements to existing systems as well as additional gear parameters that would be useful to measure.

   Conveners: Antonello Sala (CNR-ISMAR), Italy

d) A WGFTFB topic group of experts will be formed to address the issue of Innovation in fishing gear technology and the success of collaboration between fishers and scientists with the following terms of reference:

   i) Review current technological developments and initiatives in gear technology and give examples of successful developments both in the EU and in other countries globally.

   ii) Discuss the contributions of fishers and scientists in the process of collaboration and identify conditions allowing rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects.

   Conveners: Bob Van Marlen (IMARES, Netherlands) and Chris Glass (University of New Hampshire, US)

e) A WGFTFB Topic Group will be formed to address the following ToR:

i) Taking a well documented gear based technical measure; evaluate whether this measure can reduce Significant Adverse Impact for different ecosystem components using the methodology developed with WGECO and how this can be practically evaluated.

ii) If methodologies do not currently exist for some impacts, assess whether any could be developed.

Conveners: Dominic Rihan (BIM, Ireland)

4 Participants

A full list of participants is given in Annex 1. The agenda is included in Annex 2.

5 Explanatory note on meeting and report structure

The approach adopted in 2004 of addressing specific ToR's was adopted for the 2010 meeting. Individual conveners were appointed during 2009/2010 to oversee and facilitate work by correspondence throughout the year. The Chair asked the convener of each ToR to prepare a working document, reviewing the current state-of-the-art, summarizing the principal findings, identifying gaps in the knowledge where consultation with other experts was required and recommending future research needs.

Two days were allocated for the conveners and members of the individual Topic Groups to meet, finalize their reports and findings, and produce a presentation to the WG and prepare a final report for inclusion in the FTFB report. The **summaries and recommendations** for the working documents for each ToR were reviewed by WGFTFB and were accepted, rejected or modified accordingly to **reflect the views of the WGFTFB**. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB. In addition to the presentation of the review report, where appropriate, each convener was asked to select a small number (~3) of individual presentations based on specific research programmes. The abstracts are included in this report, together with the authors' names and affiliations. Although discussion relating to the **individual presentations** was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were NOT discussed fully by the group, and as such they **do not necessarily reflect the views of the WGFTFB**.

6 WGFTFB advice and requests during 2009–2010

6.1 Overview

During 2009/2010, WGFTFB dealt with the following requests for advice:

- EU request on Baltic cod selectivity
- Dutch Ministry request on the Electric Pulse Trawl.
- WGNEACS request on deep-sea fisheries
- NAFO request on redfish selectivity (due September 2010)

6.1.1 Request on Baltic cod selectivity

The Commission presented a report on selectivity for trawl fisheries for cod in the Baltic to Council in January 2009. The main conclusion of the report is that there is no data to support big differences in selectivity between the two gears Bacoma and T90°. Several member states have requested the Commission to continue assessing new

ways to increase selectivity in the Baltic cod fisheries, to reduce current levels of discards, such as an increase in mesh sizes. The Commission believes there is scope for increased selectivity and envisages more and alternative ways than simple mesh size increase.

The request concerns métiers using towed gears (trawls) and gillnets in the Baltic Cod fisheries and includes four items that are addressed individually in the text below. The four items are

- Identify current L0, L100 and L50 for gillnet and trawl fishing cod in the Baltic Sea
- Identify L50 corresponding to MSY for current exploitation levels
- Assuming that the minimum landing size remains at 38 cm what would be the corresponding L50 that would keep discards at a low level.
- What would be the short loss and long-term gain of any proposal for change in L50 that ICES may make
- What necessary gear adaptations (especially changes, for bacoma and T90, in mesh size and/or codend design) might be suggested? What alternative technical measures (e.g. spatial and/or temporal distribution of the fishing effort) should be introduced to reduce discards?

WGFTFB responded mainly to the final part of this request as detailed below in a response to ACOM in September 2009. From this and in conjunction with members of WGBFAS advice was drafted and sent to the EU. This document can be found at http://www.ices.dk/committe/acom/comwork/report/2009/Special%20Requests/EC%20Baltic%20Cod%20Selection.pdf

Gear Adaptations

Bacoma and T90 are among the most studied gear modifications in European fisheries having been the subject of extensive testing for more than a decade. The problem, however, still remains that this work has been done under different conditions with varying gear configurations in terms of twine material, twine thickness, codend circumference, on a mixture of commercial and research vessels, and using different methodologies. This continues to make direct comparison of the two gears problematical as reported previously by ICES (2007) in a response to an EU request for advice on Bacoma and T90. There is though strong evidence from the earlier analysis by ICES (Holst, 2005) and additional work carried out mainly in Poland and German to conclude that both Bacoma windows and T90 codends correctly fished as per the current regulations both give an L50 of 38–40cm, equivalent to the mls for cod of 38cm, with lower selection ranges than conventional diamond mesh codends. This is further illustrated by an analysis completed by Moderhak (2009) of data collected since 2004 with Bacoma and T90 as per the current regulations, which confirms the L50 to be around this size range for both gears, with narrow selection ranges. This analysis does highlight that for the regulation 110mm/50 meshes T90 codend construction, L50 is higher by 2 - 2.5 cm than for Bacoma 110mm/105mm and the Selection Range for T90 is 0.5 -1.0 cm lower than the Bacoma codend (Figure 1 below). This indicates that the current T90 codend is more selective although this is still subject to the underlying variability between experimental results that was apparent in previous analysis.

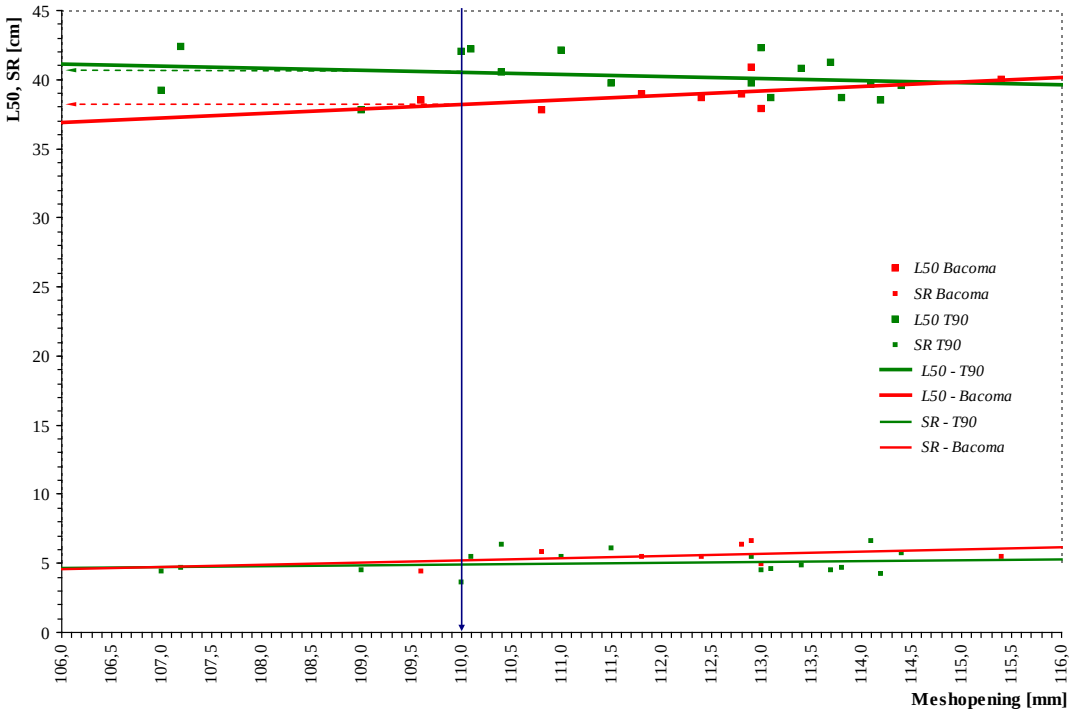

Figure 1. *L50* and *SR* vs. *MO* made for data restricted to "standard" T90 and Bacoma PE codends – Omega gauge only – CR (EC) 2187/2005

Following an assessment of the ICES response to the EU that concluded that both gears were relatively selective, STECF (2008) recommended that, "*measures resulting in improved exploitation pattern for Baltic cod be considered*". By inference this would include alterations to the existing gear regulations as well as additional technical measures such as spatial or temporal measures. Before discussing alterations to the existing gears, though, it is important for managers to clearly define what the objectives of such measures would be in terms of specific targets for the fishery, as this will make a difference to the scale of the alterations required. If the management objective is to match L25 with mls, then as ICES concluded earlier there is still potentially a mis-match between the current gears and mls which can partially be addressed through reasonably minor modifications or even through a reduction in the mls. If the objective is for a reduction of cod discards below this level then the current gears will not meet this target without fairly major modification, supplemented with other technical measures. On the basis that the overall objective is to reduce discarding to the lowest practical level based on L25, WGFTFB has carried out an assessment of the current selectivity of the two legal gears and how these could possibly be improved. In addition some alternative gear options and elements of the current regulations that should be examined are suggested.

In considering any amendments to the existing gears, WGFTFB also re-iterate the point made in the previous response to the EU on Baltic cod selectivity (ICES, 2007), which stated that, "*given the difficult and contentious evolution of the gear-based management measures in the Baltic, it is concluded that an element of caution should be exercised in making significant changes to the current regulations in the short term*". WGFTFB recommend that it is essential there is extensive industry dialogue, facilitated through the Baltic Sea RAC. Any experimental work to test alterations to the existing gears and possible alternatives should consider not only the selectivity of the gears tested but

also the practicalities of introducing such alterations, including the economic impacts. In this regard WGFTFB understand that the Baltic Sea RAC has already made a submission to the EU Commission outlining a proposed 2–3 pilot project considering measures to improve Baltic cod selectivity and this is felt to be a good initiative.

Bacoma

In January 2002, the use of a 120mm Bacoma window was introduced into the Baltic Sea. This represented a major increase in trawl selectivity but ultimately led to unsustainable catch losses of 70% by weight for trawlers (Tschernij *et al*., 2004). This resulted in the mesh size of the Bacoma window being reduced to the current 110mm/105mm codend arrangement. Trials carried out by Sweden, Poland, Germany, Denmark and two experiments in Russia over the period 1999–2004 with 120mm Bacoma windows gave an indicative L50 of ~43.6cm and a SR of ~8.9cm. This is undoubtedly an improvement in terms of matching L25 and the current mls but if introduced would result in similar high losses of marketable fish as experienced in 2002. Therefore it would seem inappropriate from an economic perspective to increase the mesh size immediately but perhaps considered on a phased basis taking account that the average lifespan of a codend/Bacoma window is around 2–3 years. This would allow a full biological, technical and economic assessment of the impact of increasing the mesh size of the Bacoma window.

Other than simply increasing the mesh size of the Bacoma window there are few other modifications that would seem appropriate to the current regulations in the short term. However, information from Swedish on-board observations and also from fishers does indicate that the size-selective properties of the current Bacoma window are unsatisfactory when catches are larger than approximately 2 tonnes (Valentinsson, 2007). The results from a study reported by Valentinsson and Tschernij (2003) did demonstrate this to some degree, showing a significant decrease in L50 with increased catches even with Bacoma 120mm windows, while showing increased selection range with increased catch weight, an indication of poorer selectivity. Despite this analysis being based on only a few data points with larger catches Valentinsson and Tschernij (2003) reported that "*the effect of large catches was evident as the catch bulk was large enough to fill up the codend above the upper end of the Bacoma window panel*". Intuitively the simple solution to this would be to increase the size of the Bacoma window (currently 3.5m). Suuronen *et al*. (2007) does report of some Swedish fishers using double-length Bacoma windows in 2005 and 2006 in an attempt to improve the codend selectivity for larger catches of small cod but there have been no specific studies that have definitively shown that extending the window length would necessarily result in such improvements.

It is worth noting work carried out investigating the relationship between catch size and codend selectivity in diamond mesh as an indication. A modelling exercise carried out by Hermann *et al*. (2007) using the simulation model PRESEMO and a meta analysis carried out by O'Neill (2008) on haddock, backed up with experimental trials (O'Neill and Kynoch, 1996; Dahm *et al*., 2002; Graham *et al*., 2004), has shown that *L*50 first increases then decreases with catch size. The scale of these increases is, however, uncertain and equally many experimental datasets have not found a dependency between selectivity and catch size. Hence it is difficult to be conclusive about the nature of such a relationship. Work by O'Neill (1997; 1999) does show that with conventional diamond mesh codends as catch increases mesh opening along the codend decreases. Adapting this model for a Bacoma window, the relationship between the length of the Bacoma panel that remains "uncovered" ahead of the catch against in-

creasing catch size can be estimated as shown in Table 1. This analysis shows that as the catch size increases the "uncovered" portion of the panel becomes shorter and shorter reducing the escape area available to a large volume of fish i.e. for a catch of 1 tonne, approximately1.64m of the panel is essentially covered by the catch leaving the other 1.86m for fish to escape and the potential escape area is reduced to 1.38m with a catch of 2.25 tonnes. Given that underwater observations have shown that fish generally try to escape as they swim in front of the bulk catch in the codend, as the escape area decreases and the catch increases the opportunities for escape are greatly reduced. This may account for the reduction of selectivity experienced with the Bacoma window.

Table 1. Relationship of catch to area of Bacoma panel left unexposed.

Catch (kg)	Exposed Panel (m)
1000	1.86
1250	1.74
1500	1.64
1750	1.54
2000	1.46
2250	1.38

Any increases in length, though, should be closely related to the length of the codend and straight extension piece commonly used in Baltic trawls. An indicative length of 5.5m (100 bars x 55mm bar length) would seem reasonable based on standard European trawl designs. Given that catches of 2 tonnes are probably an irregular occurrence on smaller vessels this perhaps should be restricted to larger vessels but this along with the appropriate length of panel needs further consultation with industry to verify. The practicalities of increasing the panel in terms of strength should also be considered.

The current regulation requires that the Bacoma window be constructed from braided knotless netting or "netting with similar selective properties". Based on the results of work carried out by Revill *et al.* (2007) in the North Sea with square mesh panels constructed in low diameter/high tenacity Dyneema twine, there may be scope to relax this part of the regulation. These trials showed square mesh panels constructed in this material to be highly selective, albeit in this case for haddock and whiting. Dyneema netting is expensive compared to conventional netting but a similar price to the Ultra Cross knotless netting commonly used for construction of Bacoma panels and is also fairly readily available. Dyneema netting does have the disadvantage of being difficult to mend due to its stiffness (see section 1.2) but used as a square mesh panel is likely to be a reasonable alternative to the heavy knotless netting required by the regulation and giving the same if not better selectivity.

T90 codends

The regulation T90 codend has shown to be selective if fished as per the current regulations. The most contentious issue, however, with the current regulation T90 codend centres on the requirement for a codend circumference of 50 meshes. There is a reasonable body of evidence to show that a reduction in codend circumference improves selectivity. The predicted effect of reducing the number of meshes round has been estimated at a reduction in L50 of ~1.7cm for an increase in codend circumference of

20 meshes (Anon., 2003). Hermann *et al.* (2007) noted that the effect of increasing or decreasing codend circumference was the principal factor in the improved selectivity associated with the T90 codend rather than alteration to mesh geometry per se. In order to compensate for the increased codend circumference due to the wider mesh opening of a T90 codend the number of T90 meshes has to be lower than for a conventional codend (Graham, in press). Reports from SINTEF in Denmark based on Flume Tank tests and information from commercial fishers suggest, however, that the current 50 meshes round regulation is flawed in that the forces become doubled on each bar reducing the strength of the codend. In addition anecdotal observations from German and Polish studies have shown large-scale meshing of fish above the T90 to diamond mesh join due to the narrowness of the codend (See Figure 2). A ratio of 3:2 (around 67 meshes) or 4:3 (75 meshes) has been put forward as an alternative to the current 50 meshes , although the effect on selectivity of such a change has not been fully tested. There is some data from a joint German/Polish cruise in 2005 that showed a 110mm T90 codend with 76 meshes in the circumference gave an L50 of 34.1cm and a SF 6.6cm and with a 67 mesh circumference gave a L50 of 35.3mm and SF of 6.0cm. From these results it is concluded that if the number of meshes in the circumference are increased then to compensate for the loss in selectivity the mesh size of the T90 may also have to be increased to compensate for the reduction in selectivity. The exact relationship between codend circumference and mesh size in T90 has not been clearly defined and it is recommended that this issue be addressed by the ICES Study Group on Turned 90º Codend Selectivity, focusing on Baltic Cod Selectivity (SGTCOD).

Figure 2. Heavy meshing of herring above a regulation T90 codend.

The other modification to the T90 codend identified that could be considered in the short term is a reduction in allowable twine thickness, currently double 4mm (codend only) or single 6mm. Using the PRESEMO model it has been shown that for standard diamond mesh codends a 1mm increase in twine diameter decreases L50 by 1cm (Hermann *et al.,* 2007). A meta-analysis of Scottish haddock selectivity data carried out by O'Neill (2008) similarly showed a 1mm increase in twine thickness decreases L50 by 1.5cm. Therefore there would seem scope to look at the effect of reducing the twine thickness of the current T90 regulation.

Weinbeck (2009) reports on recent trials with T90 codends made from low diameter/high tenacity Dyneema twines carried out in September 2008. These trials showed that these codends were highly selective with an L50 of 41cm and SR of 4.6cm with a T90 codend constructed in 2.5mm single Dyneema twine. Using the T90 Dyneema codends very low levels of cod below 38cm (~3%) although, catches of fish above mls were decreased by over 55%, which would be unacceptable to fishers. Weinbeck (2009) concluded that to give the same selective properties of the current regulation T90 codends the mesh size would need to be reduced by about 5mm. At face value this makes the use of Dyneema codends attractive from a selectivity point of view but WGFTFB would caution against such a change to the regulations in the short term. Double 4mm and single 6mm twines are widely available and used by fishers throughout Europe for the construction of codends. Whereas Dyneema has been used successfully in the construction of square mesh panels (Revill *et al.*, 2007), it is approximately ~5 times the cost of normal netting and there are practical difficulties with mending Dyneema given its latent stiffness, which does not lend itself as a good material for codend construction. In this respect it is also worth noting that according to O'Neill and Prior (in press) it is twine flexural rigidity (also known as twine bending stiffness) rather than twine thickness that ultimately determines mesh resistance to opening. Twine flexural rigidity is a function of the properties of the component fibres, the structure and the method of manufacture of the twine. By altering the structure and/or materials it is possible to produce "thin yet stiff twines" which may not necessarily be selective. The issue of twine thickness and material for T90 construction should also be referred to SGTCOD for consideration.

Fish Survival

With respect to both T90 and Bacoma windows the issue of the survival of escaping fish should also be considered. A recent study by Nowakowski *et al.* (2009) using an innovative split codend cover showed that a large proportion of the escaping fish from both Bacoma (35%) and T90 codends (37%) escaped during haul back rather than when towing. A study by Madsen (2007) also showed similar results from trials in the Kattegat/Skagerrak which compared T90 against standard diamond mesh codends. The results from these experiments showed over 50% of cod escaped from the T90 codend during haul-back compared to 34% with the diamond mesh. From a fish survival point of view this is not ideal because of the additional stress caused by decompression which is likely to increase mortality. Very little research has been conducted to assess the mortality of cod escaping at the surface other than a study by Soldal and Isaksen (1993) which showed a mortality of only 1% for cod escaping a Danish seine. This suggests this may not be a significant source of mortality but nonetheless further investigation of survival rates during the capture process should be encouraged given the potential at fleet level for this is a significant source of unaccounted mortality.

Alternative Gear Options

WGFTFB carried out an extensive review of gear modifications to reduce the bycatch of cod for NAFO in 2009 (ICES, 2009). This review identified a number of gears that can eliminate or reduce cod bycatch but found few gears that actually improved size selection of cod other than the Bacoma and T90 codends. Thus the alternative options are that could be applied in the Baltic Sea cod fishery are limited.

Diamond Mesh Codends

The most obvious alternative gear option would be to simply revert back to a diamond mesh codend, which gives an L25 equivalent to the mls of 38cm. Based on previous assessments this would equate to a codend constructed in double 4mm PE twine with 100 meshes in the circumference and a mesh size of ~135–140mm without attachments such as strengthening bags or rescue buoys as possible (Madsen, 1999; Valentinsson and Tschernij, 2003; Jorgenson *et al*., 2006; Madsen 2007). On the one hand this is a very simple solution that means all fishers using the same codend but undoubtedly would be unpopular with industry and as highlighted by Suuronen (2002) and Valentinsson and Tschernij (2003), diamond mesh codends can be easily manipulated both legally and illegally. If it was seen as an option, experiences in Norway would suggest that there should be incremental increases in mesh size from the baseline level but done on a phased basis over a period of 3–5 years.

Side Panel Codends

One modification/alternative to the Bacoma window that has been mooted by Swedish fishers is the use of side-panel codends (Valentinsson, 2009). In April - May 2009, the Swedish Board of Fisheries tested these side-panel codends, which are similar to the Swedish and Danish exit windows used previously in the Baltic prior to the introduction of the Bacoma panel (Madsen, 2007). The windows tested were 8m long square mesh panels made in standard double 4mm PE twine and with strengthening ropes along the selvedges to stabilize the square mesh (Figure 3). They were tested against a regulation Bacoma 110mm/105mm using a twin-trawl arrangement. A total of fourteen hauls were sampled with an average cod catch per haul of 1150kg. The results showed no apparent improvements in selectivity for cod without any reduction in cod discards compared to the standard Bacoma window suggesting them to be an alternative rather than a replacement for Bacoma. Further consultation with industry is planned with modifications to the gear design to be tested.

Figure 3. An 8m long square mesh side panel codend.

Rigid Grids

Another commonly used selective device that might be considered for use in the Baltic Sea would be rigid grids, which have been shown to give improvements in mean selection length for cod compared to diamond mesh codends (Jorgensen *et al*., 2006). In this respect it is worth noting the Norwegian originated design known as the 'Sort-X'™ grid system. This was designed to improve size selection of selected groundfish species including cod. Whereas the normal Nordmore shrimp sorting grid relies more on mechanical separation of species, the 'Sort-X™ grid provides a stable arrangement of escape openings in the codend region. This encourages positive escape

reactions to occur, usually based on visual stimuli. Strategic positioning of the grid combined with carefully selected bar spacing provides undersize fish with escape routes out of the gear. In recent years The Sort-V grid was developed as a user-friendlier version of the Sort-X and is now more typically used by the commercial fleets in Norway and Iceland. Both grids used have the minimum legal bar spacing of 55 mm and used with a 135mm codend giving an L50 for cod of ~55cm, equivalent to a 155cm diamond mesh codend and with a similar SR (Jørgensen *et al*., 2006). For the Baltic fishery the bar spacing would have to be reduced considerably to match the current mls but the gird has the advantage from a management point of view of being difficult to circumvent. The effect on flatfish species is not well reported in any of these studies, other than the blocking effects of large flatfish species but it is felt likely that flatfish catches are not unduly reduced by using the Sort-X™ or Sort-V grids, which is an advantage in the Baltic given the bycatch of flounder in the cod fishery. There are obvious issues of practicalities for Baltic Sea vessels in particular for smaller vessels but many of these issues have been resolved in Norway and Iceland so these are not felt to be insurmountable.

Gear Attachments

WGFTFB re-iterates the point made in the earlier response to the EU on Baltic cod selectivity regarding the use of gear attachments (ICES, 2007). Under Article 5 of Regulation 2187/2005, several legal gear attachments are described that may have an adverse effect on selectivity or can be rigged in an illegal manner to restrict mesh opening. The use of bottom side chafers, large "rescue" floats attached to the codline, flappers and round straps all have an effect on selectivity depending on how they are rigged and the continued need for such attachments on strength and safety grounds should be balanced against their negative effects on selectivity, whether with a Bacoma window, T90 codend or diamond mesh codend.

Gillnets

A minimum mesh size of 105mm was introduced in the Baltic cod gillnet fishery for the first time in 1990 (Madsen, 2007). From 2002 the minimum mesh size was increased to 110 mm and this is the current regulation (Madsen, 2007). Few studies have accurately measured the selectivity of gillnets used in the Baltic Sea but the L50 for 105mm and 110mm gillnets has been estimated at 43.4–45.5cm respectively by Madsen (2007) using a bi-normal selection curve. This is higher than for trawls and is comparable to the L50 of a standard 140mm codend. The selection curve is relatively steep compared to trawls (Madsen, 2007) and it is reported that many gillnet fishers use larger mesh sizes than the minimum allowed, possibly reflecting the availability of materials. The L25s for a standard twine (1.5x4 thread, 50% hanging ratio) and for a range of mesh sizes has been calculated from this earlier analysis and are provided in Table 2 below. This shows this is well in excess of the current mls for the range of mesh sizes.

Table 2. Predicted L25 for a range of gillnet mesh sizes.

Mesh Size (mm)	Predicted L25 (cm)
105mm	40.9
110mm	42.8
120mm	46.7
130mm	50.6
140mm	54.5
150mm	58.4
160mm	62.3
170mm	66.2
180mm	70.1

Studies by Holst *et al.* (2002) and Wileman *et al.* (2000) have shown parameters such as twine thickness, hanging ratio and season have relatively little effect on the selectivity of Baltic cod gillnets. Madsen (2007) showed in experiments testing different gillnets with varying twine thicknesses that from a management point of view the actual effect of twine thickness on selectivity was so limited that it does not have to be considered as an important parameter. Several studies have shown that the fishing power (i.e. the ability to retain fish at the optimal modal length) of a gillnet is highly dependent upon the twine diameter with thinner twines catching larger numbers of fish (Hamley 1975; Wileman *et al*., 2000) but none affect selectivity. Madsen (2007) concludes that it is relatively easy to improve size selectivity in the gillnet fishery by simply increasing the mesh sizes, because the other technical parameters don't influence selectivity to any great degree, as in trawl fisheries. On this basis WGFTFB see little reason to alter the current gillnet regulations. The L25 for the current legal gear is in excess of mls and the restrictions on length of gear and soak time seem in line with similar fisheries in other parts of Europe. However, WGFTFB do note the concerns expressed by Suuronen *et al*. (2007) that if trawl size selectivity is improved and the numbers of larger cod increase, then it is reasonable to assume that the gillnet vessels would catch a major part of those fish given previous experience has shown larger cod tend to be found on fishing grounds where trawling is not possible. This could lead to increases in effort in gillnet fishery, which ultimately could have a detrimental effect on the stock by removing too many of the large fish in the population.

Alternative Management Measures

The Baltic cod fishery is a relatively simple single species fishery, which is well studied. It would seem a candidate fishery to move to a target based system, allowing fishers to adjust their gear or fishing pattern to meet appropriate management targets set for the fishery. This would remove the need for the large-scale and frequent changes to the current technical measures regulations, which have occurred over the last decade in the Baltic cod fishery and caused many of the current problems. It would allow fishers to use the gears that most suit their operation and fine-tune them to suit the situation on the grounds. It would appear according to comments by Weinbeck (2009) and Suuronen *et al.* (2007) there is already evidence to some degree of this with fishers voluntarily using more selective gears to reduce discarding e.g. 125mm T90 codends and double Bacoma windows. This target based approach also has the advantage of being able to do away with a lot of the very complicated and prescriptive text within the current regulation e.g. the detailed descriptions of how to mend a Bacoma panel can be removed. It also subverts the emotive argument that

has continued regarding whether the Bacoma or T90 codend is the better gear solution. The monitoring and "burden of proof" element of such an approach is of course critical as are the incentives to encourage fishers to comply but it is felt the Baltic RAC could play an important role in developing such a system and encouraging cooperation. Elements of a target based approach are already included in the Baltic Sea RAC proposals sent to the Commission (Clink, pers. comm.) and could be developed further.

Conclusions

The conclusion from the earlier ICES response on the relative selectivity of Bacoma and T90 remains. Both are selective but as has been discussed could potentially be modified to improve selectivity. Several alternatives including a return to a simple large diamond mesh codend or the use of side panel codends or a rigid grid are also put forward.

For the Bacoma it seems the most sensible modifications would be to consider extending the length of the panel to maintain selectivity with larger catches and/or increase the mesh size of the panel. There are some field observations and evidence from modelling data to support this move but without further studies the effectiveness of this modification is unproven. The practicalities of extending the length of the window, particularly for smaller vessels also need to be considered. There is also merit in considering increasing the mesh size of the Bacoma window to 120mm to better match L25 to the current mls. This, however, should only be done on a phased basis and with due regard to the potential economic losses that may occur.

There is reasonable evidence to show that the current regulation T90 codend gives an L25 close to the current mls. The current legal limit for the codend circumference of 50 meshes does seem to be problematical though, with respect to strength and meshing of fish and there is a case for increasing the number of meshes allowed to address this issue. Studies have shown that there is a strong link between the selectivity of T90 codends and codend circumference so an increase in this parameter may have to be balanced with an increase in mesh size. Twine thickness and material used in the construction of T90 codends also have a bearing on selectivity and studies have shown using low diameter/high tenacity twines can increase the selectivity of T90 codends. The cost of such materials and practical handling difficulties, however, make the use of such materials seem impractical at the current time.

Regarding other gear modifications only the Swedish side panel codends and rigid grids seem options that could be tested further, although indications with the side panel codends is that they will only give as good a selectivity as the current Bacoma windows without out further modification, while grids may not be a practical option on Baltic Sea vessels.

A more obvious alternative gear option would be to revert back to a diamond mesh codend regulation, which gives an L25 equivalent to the mls of 38cm. Based on previous assessments this would equate to a codend of ~135–140mm. On the one hand this is a very simple solution that means all fishers using the same codend but undoubtedly would be unpopular and can be easily manipulated both legally and illegally.

It is relatively easy to improve size selectivity in the gillnet fishery by simply increasing the mesh sizes, because the other technical parameters don't influence selectivity to any great degree, as in trawl fisheries. On this basis there seems little reason to

alter the current gillnet regulations. The L25 for the current legal gear is in excess of mls and the restrictions on length of gear and soak time seem in line with similar fisheries in other parts of Europe.

Leaving aside the suggestions for improving the current gears and alternatives the fact that the Baltic cod fishery is essentially a simple single species fishery, means it is an ideal candidate to manage through a target based approach. It is concluded that this should be explored further with the Baltic Sea RAC as an alternative management plan for the fishery.

Recommendations

1. WGFTFB recommend that increasing the length and/or the mesh size of the Bacoma window be explored with direct industry input. This should be considered on a phased basis taking account that the average lifespan of a codend/Bacoma window is around 2–3 years and to allow a full biological, technical and economic assessment of the impact of such changes.
2. WGFTFB recommend that consideration be given to relaxing the requirements in the regulation for using at least 5mm twine diameter material for construction of Bacoma windows. To allow the use of low diameter/high tenacity twines instead.
3. WGFTFB recommend that ICES SGTCOD assess the appropriate circumference and mesh size to give the required selectivity for T90 codends based on all available information.
4. WGFTFB also similarly recommend the current twine thickness provisions for T90 codends should remain as currently specified but SGTCOD carry out an assessment to ascertain whether a reduction in twine thickness would be a positive modification in future. This should include an assessment of the suitability for low diameter/high tenacity twines for codend construction.
5. WGFTFB recommend that further studies investigating the survival of escaping fish from Bacoma, T90 and diamond mesh codends throughout the capture process be instigated.
6. WGFTFB recommend that the benefits of reverting back to a diamond mesh codend on a phased basis instead of Bacoma and T90 be considered. This should be explored with industry input.
7. WGFTFB recommend a review of the current regulations regarding permissible gear attachments e.g. chafers, rescue floats etc. be carried out in order to establish whether there is a continued need for their use.
8. WGFTFB recommend that consideration be given to carrying out trials with rigid grids modified to suit Baltic Sea conditions tested against a Bacoma and T90 codend.
9. WGFTFB recommend no alterations to the current gillnet regulations are required, although there should be close monitoring of the effort levels.
10. WGFTFB recommend the possibility of adopting a target based management system be explored with the Baltic Sea RAC.

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6.1.3 Response to The Netherlands' request on Electric Pulse Trawl

Request

The Netherlands requested ICES to review experimental results aimed at advancing knowledge of the ecosystem effects of electric pulse trawls. Limited use of these trawls has been granted to The Netherlands via EC derogation. In response to the request, ICES arranged for the experimental results to be reviewed by appropriate experts.

Response

Based on the expert reviews, ICES concludes that:

1) The experiments are a valuable further step to evaluate the ecosystem effects of fishing with pulse trawls.

2) Laboratory experiments on elasmobranchs, benthic invertebrates, and cod to test the effects of electric pulses were generally well designed and interpreted correctly. However, the experimental results have some weaknesses as discussed below.

3) The experiments indicate minimal effects on elasmobranchs and benthic invertebrates.

4) Electric pulses resulted in vertebral injuries and death of some cod which were in proximity (<20 cm) to the conductor emitting the electric pulses. There is inconclusive evidence that the capture efficiency of cod by pulse trawls is higher than for conventional beam trawls (see attached review by Norman Graham). Widespread use of the pulse trawl has the potential to increase fishing mortality on cod as a result of injuries caused by electric pulses (and possibly higher capture efficiency) but further research is needed to draw firm conclusions.

5) While the results of laboratory experiments are informative, many factors could result in different effects during actual fishing operations. In particular, specifications contained in the derogation for the pulse trawl allow a wider range of electric pulse characteristics than were tested in the experiments. Therefore, pulse trawls permitted under the EC derogation may generate substantially different effects than those observed in the experiments.

6) This advice is narrowly based on the review of three reports provided by The Netherlands. Concerns and uncertainties raised in the advice may be addressed by further research, refinement of the derogation, and monitoring the fishing operations and performance of vessels using pulse trawls.

Background

In March 2006, ICES received a request from The European Commission to provide scientific advice relating to the use of beam trawls equipped with the capability to generate an electric pulse aimed at stimulating flatfish to enhance their vulnerability to the gear. ICES was specifically asked to give advice on the ecosystem effects of allowing electric pulse trawling on a commercial scale.

The request was considered by an *ad hoc* subgroup of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) in April 2006 (ICES, 2006). Based on the group's report, ICES gave advice in May 2006 which is summarized as follows:

- *"The available information shows that the pulse trawl gear could cause a reduction in catch rate (kg/hr) of undersized sole, compared to standard beam trawls. Catch rates of marketable sole above the minimum landing size from research vessel trials were higher but commercial trials suggested lower catch rates. Plaice catch rates also decreased for all size classes. No firm conclusions could be drawn for other species but there was a tendency for lower catch rates"*
- *"Because of the lighter gear and the lower towing speed, there is a considerable reduction in fuel consumption and the swept-area per hour is lower".*
- *The gear seems to reduce catches of benthic invertebrates and lower trawl path mortality of some in-fauna species.*
- *There are indications that the gear could inflict increased mortality on target and non-target species that contact the gear but are not retained.*
- *The pulse trawl gear has some preferable properties compared to the standard beam trawl with tickler chains but the potential for inflicting an increased unaccounted mortality on target and non-target species requires additional experiments before final conclusions can be drawn on the likely overall ecosystem effects of this gear".*

ICES therefore made recommendations on additional data needed:

- *"Further tank experiments are needed to determine whether injury is being caused to fish escaping from the pulse trawl gear. The experiments need to be conducted on a range of target and non-target fish species that are typically encountered by the beam trawl gear and with different length classes. In these trials it should be ensured that the exposure matches the situation in situ during a passage of the pulse beam trawl. Fish should be subjected to both external and internal examination after exposure".*
- *"If the pulse trawl were to be introduced into the commercial fishery, there would be a need to closely monitor the fishery with a focus on the technological development and bycatch properties".*

The Report of the WGFTFB Ad hoc Group specifically mentioned potential spinal damage to cod exposed to electrical stimulation, potential effects on invertebrates and possible disruption of the electric sensory systems of elasmobranchs. Subsequently, the European Commission granted the Netherlands derogation for 5% of the fleet to use the pulse trawl on a restricted basis provided attempts were made to address the concerns expressed by ICES. This derogation has been granted every year since 2007.

The Netherlands (specifically IMARES) has studied the effect of the electric pulse trawl during the period 2007–2009 to fill these gaps in knowledge through a series of tank experiments on elasmobranchs, invertebrates and cod. The experimental species were subjected to electrical stimuli believe to be representative of *in situ* fishing conditions. The findings from these experiments are given in three reports:

1) The effect of pulse stimulation on biota – Research in relation to ICES advice – Progress report on the effects to cod (De Haan *et al*., 2009a).

2) The effects of pulse stimulation on biota – Research in relation to ICES advice – Effects on dogfish (De Haan *et al*., 2009b).

3) The effect of pulse stimulation on marine biota – Research in relation to ICES advice – Progress report on the effects on benthic invertebrates (Van Marlen *et al*., 2009)

In consultation with the European Commission, in September 2009 The Netherlands requested ICES to review the reports and to provide updated advice on the ecosystem effects of the pulse trawl. The reports were independently reviewed by a group of experts in the fields of electric fishing techniques, fishing gear technology, benthic ecology, unaccounted mortality and fish survival experimentation. The reviewers were specifically requested to consider the questions raised by ICES in the 2006 advice and whether the additional experiments had successfully addressed these issues. The full reviews can be found at http://www.ices.dk/committe/acom/comwork/report/2009/Special%20Requests/Netherlands%20Pulse%20Trawl.pdf.

The following is a summary of issue raised by the reviews that ICES considers worthwhile to highlight:

1) The work carried out by IMARES as a response to the ICES advice on pulse trawling is notable for the high quality of the experiments. Detailed measurements of electric field parameters both in natural environment and during the experiments are noteworthy. A particular attention was given to the control groups of animals which were subjected to the same manipulations as the test groups but not electrically exposed to minimize the influence of transfer and handling. An additional positive point of the study is the use of an electric pulse simulator with pulse characteristics

similar to the commercial Verburg pulse system. The numbers of fish both in the test and control samples were adequate. The presentation of the mortality results (as proportions), as well as the occurrence of spinal injuries in cod, along with their associated binomial confidence intervals (at 95%, say; using "Statxact" for example) is informative. Moreover, at the same time a simple power analysis could be performed indicating the necessary sample size for future experiments (based on the deviance in these preliminary results).

2) With respect to benthic invertebrates, the results clearly show a low level of impact on the complete range of species tested. These species are considered representative of those encountered in the beam trawl fisheries. Based on all known literature on the expected mortalities of such species from traditional tickler chain beam trawls, it is therefore reasonable to assume that the impact of a pulse trawl with a pulse configuration corresponding to the experimental pulses on benthic invertebrates is less by a higher order of magnitude. It is important, however, that for the gear to be used with low impact that the existing prohibition on the addition of tickler chains in front of the electrode arrangements contained in the EU derogation should be maintained. Otherwise, tickler chains will cause additional ecosystem impact.

3) The experiments carried out on elasmobranchs show only a very limited effect on the species tested and it is unlikely the pulse trawl system will have a major impact on elsamobranch species. It was shown that general well-being of exposed dogfish was good in that they produced eggs and exhibited no aberrant feeding behaviour.

4) The results show that the system is capable of inflicting vertebral damage leading to mortality of cod that were in proximity (<20 cm) of the conductors. Also, inconclusive evidence suggest that the system may have a higher fishing efficiency for cod than the conventional gear (See attached review by Norman Graham of De Haan D., van Marlen B., Kristiansen T.S., Fosseidengen J.E., 2009a in Annex 1), but further research is needed to address this question and reduce cod mortality.

5) The derogation for use of the pulse trawl in Council Regulation (EC) No 43/2009 defines the voltage (V) and current power(KW =V*A) that can be used. However, it is not altogether clear from the reports how representative the experimental set up is with respect to the limits set within the derogation. The author's note that the tank tests were conducted "with pulse characteristics equivalent to the nominal menu settings….which represent the average settings of the pulse properties…." They then go on to note that these can be varied by +/- 20%. This raises concerns that the full range of settings were not tested and it is unclear what the impact of the 'maximum' setting could be.

6) ICES previously advised that the effects across different length classes encountered by the fishery should be considered. This issue has only been partially addressed as the experiments on cod were conducted on a narrow range of fish (41–55cm). Fish length has been shown to be important in terms of reaction and the results cannot be extrapolated beyond the length groups tested. The effects on small fish and larger fish can only be estimated based on previous experimentation and in this respect the authors refer to the work by Stewart (1975), which showed lower effects for smaller

fish. Based on all known literature, large fish are expected to be more negatively affected (e.g. more vertebral damage; Snyder, 2003). The relative impact on the catchability of larger fish is unclear.

7) Due to commercial confidentiality, details on the pulse frequency, pulse shape, pulse duration, voltage/power of the pulse trawl is not widely available which hinders review of the potential impact of the system on target and non-target species. All of these factors are important as discussed by Snyder (2003).

8) It is also noted that the specifications in the derogation granted by the EC are not specific enough to assure that the results of the experiments discussed in this advice are applicable to all of the pulse trawls allowed under the derogation.

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6.1.5 Response to WGNEACS on Exploratory Fishing Protocols

In 2008, NEACF adopted recommendation XVI on bottom fishing activities in the NEAFC regulatory areas, which includes procedures for fishing activities in new bottom fishing areas. In areas not previously impacted by bottom fishing gear, fishing should be considered exploratory and shall be conducted in accordance with an Exploratory Bottom Fisheries Protocol. Proposed bottom fishing activities shall be subject to an impact assessment that would determine whether there are significant adverse impacts on vulnerable marine ecosystems (VMEs). Prior to the agreement of an NEACF Exploratory Bottom Fisheries Protocol, an interim protocol, published in Annex 1 of recommendations XVI is to be followed. This protocol is as follows:

Until the Commission adopts a new protocol in accordance with Article 4, paragraph 1 of this Recommendation, exploratory bottom fisheries may commence only when the following information has been provided to the Secretary by the relevant Contracting Party:

(a) A harvesting plan which outlines target species, dates and areas. Area and effort restrictions shall be considered to ensure fisheries occur on a gradual basis in a limited geographical area.

(b) A mitigation plan including measures to prevent significant adverse impact to vulnerable marine ecosystems that may be encountered during the fishery.

(c) A catch monitoring plan that includes recording/reporting of all species caught. The recording/reporting of catch shall be sufficiently detailed to conduct an assessment of activity, if required.

(d) A data collection plan to facilitate the identification of vulnerable marine ecosystems/species in the area fished.

WGFTFB were asked by WGNEACS to comment primarily on points (b) and (d).

WGFTFB Response

In responding to this request, WGFTFB have split this into five areas as follows:

1) Gear Descriptors
2) Potential Mitigation Measures – Towed Gears
3) Impacts of Static Gears
4) Gear Selectivity
5) Gear Monitoring

Gear Descriptors

Provided below are a list of gear parameters that should be included in any proposed mitigation plan to allow preliminary assessment as to whether the gears intended to be used have the potential to result in significant adverse impact on vulnerable marine ecosystems. In addition these parameters should also be recorded routinely by observers on deep-sea fishing vessels, as well as any gear modifications made during any voyage.

Towed Gears

Trawl

Fishing Circle (number of meshes in the circumference x mesh size)

Floatation (number and diameter)

Codend and extension (mesh size and material)

Groundgear

Length (including chain extensions)

Number of Diameter of Discs or bobbins

Spacing (including packers used)

Presence or absence of tickler chains

Attachment to fishing line

Bridles and Sweeps

Construction material

Length

Diameter

Warp

Diameter

Trawl Doors

Type (Make, model)

Size (length x breadth)

Weight (estimated)

Rigging (Backstrops and warp attachments)

Ancillaries

Clump Weight (Type, weight)

Wingend or Warp end weights (Type, weight and position)

Static Gears

Gillnets

Dimensions of individual nets (Length x no of meshes deep x hanging ratio)

Number of nets per fleet

Number of fleets

Mesh size and material

Anchors (number, weight, design)

Longlines

Number of Hooks per line

Number of lines per fleet

Number of fleets

Hook size and pattern

Anchors (number, weight, design)

Pots

Number of Pots per string/fleet

Number of Fleets

Pot description (shape, mesh size, entrance)

Anchors (number, weight, design)

Mitigation Measures – Towed Gears

Measures to mitigate benthic impact by towed fishing gear are reported by Rose *et al.*, 2000; He 2001; Løkkeborg, 2005; Glass *et al.*, 2007 He, 2007 and others. However, due to the complexity and the methodological limitations of most impact studies, the results from individual experiments should be interpreted with great caution as described by Løkkeborg (2005) and in particular to vulnerable marine ecosystems in the deep seas. Nevertheless there are a number of gear modifications that have been tested and found to reduce benthic impact and are felt worth of mentioning in the context of VME's. Whether these would be effective would of course depend on species being targeted and the benthic habitats encountered in all cases.

These modifications include the use of:

- semi-pelagic trawls;
- groundgear modifications;

- low impact trawl door designs; and
- bridle modifications.

Semi-pelagic Trawls: Lifting the groundgear off the seabed can be achieved by attaching the top bridles directly onto the main warps, forward of the doors e.g. Fork rigging (He and Winger, 2010). This technique was originally developed for targeting fish off the bottom or for towing over uneven ground to reduce gear damage and therefore may have applications in the deep sea, depending on target species. This method reduces bottom contact from the groundgear but not necessarily the doors which still maintain contact with the seabed. A similar effect can be achieved by replacing traditional groundgears with a series of drop chains and weights. This significantly lightens the trawl and has been tested to good effect in fisheries for red snapper in northern Australia (Brewer *et al.*, 1996). This rigging lifts the fishing line clear of the bottom and leaves only a series of shallow furrows. Whether this is applicable to deep-sea fisheries is again dependent on target species and prevailing bottom conditions i.e. the drop chains may still damage large sessile structures.

Groundgear Modifications: There have been several different groundgear modifications tested that seek to minimize the area and depth of the footprint made by the groundgear. This is generally done by reducing the number of contact points that impact on the seabed. Some of these are really only suitable for light trawls and for species such as shrimp, prawns or flatfish so are not reported here but experiments have shown that it is possible to reduce the number of footgear bobbins without significantly altering the engineering and catch performance of the gear (He, 2001). In these experiments the area affected by the bobbin footrope was reduced by 69% when the number of bobbins was reduced from 31 to 9. However, in adverse sea and ground conditions, the experimental footrope did not work well and gear damage was found to be excessive. This rig is probably only suitable under favourable sea and fishing ground conditions (He and Winger, 2010). A number of researchers have also looked at roller, wheels and plates. Of most relevance is the work carried out in Denmark and Norway to develop a "plate" groundgear. This groundgear has an increased spreading force allowing door size to be reduced and thus reducing impact. In addition, because the individual plates can flip horizontally in reaction to rocks or other such obstructions, this gear appears to be less intrusive to the bottom. This was tested during a recent EU project entitled "Degree" and tested a standard rock-hopper footrope against the plate gear. The trials indicated that the plate gear trawl had a lower impact on the bottom substratum and benthic organisms than the conventional rock-hopper trawl. The physical impact on the bottom was visually inspected and measured using ROVs. In addition the turbidity of the water volume above the trawl tracks at different time-steps after trawling was measured. A higher turbidity above the rock-hopper trawl path indicated that the rock-hopper gear raised more sediments than the plate gear trawl (Anon., 2009). Whether either of these modifications are applicable to VME's, however, is untested.

Low impact trawl door designs: A number of newer semi-pelagic trawl door designs, which rely primarily on hydrodynamic forces to spread the trawl and usually have a higher aspect ratio (ratio of height to width) allow doors to fished stably both off and on the bottom. Such designs are now commonly used as are pelagic "Superkrub" doors. For fisheries where herding by sand clouds form the doors are not critical, the use of such doors fished off bottom is feasible and can reduce seabed disturbance. This again was demonstrated in the DEGREE project (Anon., 2009). Such doors also reduce the bottom contact of sweeps behind the door off the seabed (Goudey and

Loverich, 1987). However, in some rigging, depressor weights are sometimes attached to the bridles at a midpoint between the doors and the trawl. Thus while the doors are off the bottom there is still contact from these weights.

Bridle Modifications: Bridles have a lesser impact than the doors and groundgears but nonetheless do create a level of benthic impact. In fisheries for species in which bridle herding is not important then shorter or lighter bridles can be used. Alternatively bridles can be rigged to reduce the effect on sessile animals as tested by Rose *et al*. (2006). In this case to raise the cable off the seabed and to reduce the cutting effect of the cable to sessile animals' disc clusters were placed on the bridles, effectively lifting them off the bottom.

Static Gears

The effect of gillnet and longline fisheries on the benthic community is expected to be fairly low, whereas the fish community may suffer strong effects from the removal of large fish. The direct damage of fixed gears on benthic habitats is thought to be small and caused by individual anchors, weights and groundgear (ICES, 2006). If habitat damage by gillnet fisheries occur, it is most likely to be due to abrasion and/or translocation of seabed features by lost nets (Brown and Macfadyen, 2007), breaking or uprooting structures when hauling or setting anchors and buoy ropes (Chuenpagdee *et al*., 2003). Therefore no mitigation measures are suggested here for VME's.

Mortality of benthic invertebrates can be caused through a series of mechanisms for bottom-set gillnets and longlines. Direct catch mortality can be high for crustaceans (e.g. Sundet, 1999; Large *et al*., 2009), but is generally thought to be negligible (e.g. Santos *et al*., 2002). Again, this is very much area-dependent. Another mechanism through which benthic invertebrates are impacted is by ghost-fishing nets. These can increase food availability for scavengers and/or result in catching, for instance crustaceans, by closing meshes around them (Kaiser *et al*., 1996; Revill and Dunlin, 2003; Brown and Macfadyen, 2007; Graham *et al*., 2008). For non-commercial fish species, no major assessments have been found, although indications of discards exist in some areas (Santos *et al*., 2002; Hareide *et al*., 2005). Mitigation against ghost netting is easily achieved through good fishing practice and recording. The retrieval of lost nets can be achieved by using creeper gear and this has been extensively reported by Brown and Macfadyen, 2007 and Graham *et al*., 2008.

Gear Selectivity

Very little is known about the selectivity of towed gears in deep-sea fisheries, although due to the morphology, generally sedentary behaviour and low light lives frequented by many deep-sea species it is doubtful that simple mitigation measures such as large codend mesh sizes or square mesh panels would be particularly effective in such fisheries. Moreover it is also felt likely that the survival of escaping fish in any case would be low, leading to unaccounted mortality. Sorting grids maybe applicable in some fisheries and are already used in some redfish and deep-water prawn fisheries for size and species selection. It is therefore recommended that codend mesh size used in such fisheries should be well matched to the target species and sorting grids considered in single species fisheries.

Gear Monitoring

There have been a number of developments in gear monitoring systems that have relevance for monitoring and mitigation against benthic impact. There are several

systems that allow monitoring of the position of the trawl relative to the seabed based on information from the echosounder and the sonar. One example is the system developed by Simrad in Spain that can monitor fishing parameters and their geographical position of each sensor (installed on the doors and the headrope) of trawl gear relative to a gas pipeline in this case. See http://www.simrad.com/www/01/NOKBG0238.nsf/AllWeb/DAEB7455E3801C3BC125758C001B6719?OpenDocument for more details. This type of approach could well be useful in controlling and monitoring gear usage to demonstrate avoidance of VME's at a much finer resolution than traditional VMS could ever do. In the case of the Simrad project such information is being sent back to a land-based server in real-time.

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6.1.7 Response to NAFO on Redfish Selectivity

Background

At the NAFO Science Committee meeting of September 2009, the issue of redfish escapement from trawl nets at the surface during the latter stages of hauling was discussed and noted in their report:

"Fisheries Commission requested Scientific Council to examine the consequences resulting from a decrease in mesh size in the midwater trawl fishery for redfish in Div. 3M, to 100 mm or lower (Annex 1, Item 13). Scientific Council reviewed a re-analysis of existing trawl selectivity data from pelagic trawl fisheries conducted from 1978–2005 by PINRO Russia for deepwater redfish (SCR Doc. 09/52). Scientific Council was informed that square mesh codends were used in these experiments and could not utilize the results in light of the predominantly diamond mesh codends in use for midwater trawling in the NRA. Scientific Council noted that further mesh selectivity experiments are planned by Russian Federation and, therefore, Scientific Council deferred providing advice at this time and will revisit this request in 2010 meeting when it is anticipated the results of these experiments would be available".

It was noted that a codend containing redfish rapidly rises to the surface due to hydrostatic pressures and rather special conditions develop within the codend that results in the tension being taken off the meshes, thus allow them to open up and cause fish loss. It was therefore felt that the change of mesh size alone may not be a solution to the problem, and that some other gear modification may be more effective. Therefore, Scientific Council recommended that the loss of redfish by midwater and bottom trawls, during the later stages of hauling when the net comes to the surface, be referred to the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) to investigate possible technical measures that could reduce the loss of redfish at the surface due to their developed buoyancy.

Specifically WGFTFB were asked to comment on possible gear modifications to reduce escapement at the surface or allow escapement at depth.

WGFTFB considered this request initially at the 2010 meeting and indicated to NAFO that they will formulate an initial response by September 2010. WGFTFB also advise that WGQAF should also be asked to comment on this request given the implications on unaccounted mortality. It should also be noted that WGFTFB felt that the issue of redfish selectivity/escapement was an issue of increasing importance for a number of countries and therefore have proposed a ToR for 2011 as detailed in Annex 4.

7 Report from FAO

Development of the International Guidelines on Bycatch Management and Reduction of Discards

(Petri Suuronen, FAO Fishing Operations and Technology Service, FIRO)

High levels of bycatch and discards exist in many fisheries and in recent years, juveniles of ecologically important and economically valuable fish are targeted and landed, much of which is used as aquafeeds, low in value and commonly referred to as trash fish. Excessive bycatch can (1) threaten the long-term sustainability of fisheries, (2) decrease food security, and (3) negatively affect the livelihoods of millions of fishers and fish workers that depend on fish as a source of food and livelihood. There are many challenges in managing bycatch including a paucity of quantitive data on bycatch species and their socio-economic importance. Major constraints to manage bycatch and implement mitigation measures include economic disincentives, poor awareness of, and limited financial and human resources to develop and implement bycatch management and discard reduction actions.

Concerns over bycatch have been expressed in United Nations General Assembly Sustainable Fisheries Resolution, most recently in A/RES/64/72 which calls for action on bycatch and discards. A/RES/64/72 also welcomes the support of the Committee on Fisheries at its twenty-eighth session to develop "International Guidelines on Bycatch Management and Reduction of Discards". In this regard, an Expert Consultation held in November-December 2009 (FAO Fisheries Report no. 934) provided the initial forum for producing a draft text of the guidelines. The Expert Consultation concluded that following actions be taken to improve the management of bycatch and reduce discards: (1) Quantify bycatch and discards; (2) Identify best practices; (3) Facilitate access to technical information and support; (4) Provide guidance in data collection; and (5) Communicate to the fisheries sector and the public.

The Expert Consultation proposed that the main elements of International Guidelines consider: (1) Governance and institutional frameworks, (2) Bycatch management plans, (3) Data collection, reporting and assessment; (4) Monitoring Control and Surveillance (MCS), (5) Research and development on bycatch mitigation and discard reduction technologies, (6) promotion and awareness raising, (7) Communication and capacity building, and (8) Special requirements of developing States. The Expert Consultation concluded that the performance of bycatch management measures is case specific and a few universal solutions exist.

A Technical Consultation will be held from 6–10 December 2010 to further develop the draft Guidelines which will be submitted to COFI for their consideration.

Report of ICES/FAO group on Fishing Gear Classification

An International Standard Statistical Classification of Fishing Gear (ISSCFG) was originally drawn up in 1971 and adopted by the Coordinating Working Party on Fishery Statistics (CWP) sponsored by FAO/ICES/ICNAF in 1980, with the primary aim of helping to prepare statistics on fish catches by gear type in the North Atlantic Area. A revised edition was published in 1990 (FAO Technical Report 222/Rev.1). At the instigation of FAO, a group of technical experts was formed from the ICES/FAO Working Group on Fishing Technology and Fish Behaviour to advise on updating the technical content of the publication. The group met in Rome (2005) and Izmir (2006).

A revised draft of the text was prepared prior to the WGFTFB meeting in Dublin (April 2007) and subsequently a completely new set of illustrations was commissioned by FAO from SEAFDEC during 2008/09. A further revision of the text was circulated in March 2009. At the ICES/FAO WGFTFB meeting in Ancona Italy (May 2009), a meeting was held between WGFTFB members and the Secretary of CWP to coordinate the process of finalizing the revision.

The meeting agreed on the following actions regarding the gear classification:

- To revise the hierarchy of gear types such that only 2 levels are specified, allowing a third level to be introduced for e.g. regional variations
- To take account of comments by the FAO customer (CWP) and others on additional categories of gear types and make final amendments to the current list accordingly; to draft new text as required
- To set up a group of experts to comment on the illustrations and integrate them into the text
- To identify an expert to assess whether the current gear categories are adequate for inland fisheries
- To put forward proposals, where necessary, to amend the alphanumeric abbreviations as well as the number codes associated with each gear type
- To obtain comments on a final draft from a panel of referees including S. Walsh, E. Dahm and J. W. Valdemarsen
- To submit the draft as a proposal to CWP by end October 2009 with a view to its being considered for adoption at the next CWP meeting in February 2010
- The CWP Secretary to alert CWP members that a proposal for a new text was in the pipeline

Follow up actions from ICES FTFB 2009

1) Mr Chopin to liaise with SEAFDEC on modifications to illustrations. At the Ancona side meeting, SEAFDEC were provided with editorial changes to illustrations and SEAFDEC were asked to update drafts. A further meeting was held in Bangkok (Nov 2009) – Chopin met with SEAFDEC illustrator and Mr Bundit Chokesanguan to make further revisions. SEAFDEC provided second revision.

2) Mr Ferro to coordinate completion of FAO TP 222 Rev. 1 text revisions and changes to illustrations – it was hoped that SEAFDEC would join ICES FTFB 2010 meeting and to have Mr Ferro work with SEAFDEC towards finalizing the illustrations. This has been postponed but must be completed before CWP meeting (see point 3)

3) Ms Tsuji to inform the progress to CWP members and arrange to submit the proposal of ISSCFG amendments in accordance with revised FAO TP 222 Rev. 1 to the next CWP Session seeking their approval.

CWP meeting with respect to ISSCFG codes and text of FT 222.

The reason for involving CWP is that FT 222 contains the International Standard Statistical Classification of Fishing Gears Codes and that these codes were adopted by CWP in 1980 and form an important link between the fishing gear categories and codes used for statistical reporting. Accordingly, they represent an important element

of the FT 222 and its use by fisheries statisticians and others monitoring catches and landings.

For the above reason, and because the domain of ISSCFG lies within CWP, any changes to the classification system or their associated codes should go through CWP. [This issue was raised in FTFB in 2008 and also 2009].

As discussed at the FTFB meeting in Ancona, Sachiko Tsuji (FAO and CWP Secretary) would raise the issue of the revision of FT 222 at the meeting of CWP in Hobart, Australia (CWP 23) at which representatives of both ICES and SEAFDEC would be present.

Next Steps (CWP Secretary):

1) CWP to convene an Ad-hoc Group for developing the draft revision of CWP Gear Classification

2) FAO, ICES, and SEAFDEC are expected and requested to nominate at least one expert to participate in the Ad-hoc group

3) The Secretary will deliver the name of the Coordinator and composition of the Group to participating organizations as the earliest possible after April 15, 2010.

4) CWP secretary will inform ICES FTFB and SEAFDEC of the procedures for the group

5) The ToRs of the group develop a draft proposal for revision of ISSCFG for both alphabetic and numeric codes.

Low Impact Fuel Efficient Fishing (LIFE)

(Petri Suuronen, FAO Fishing Operations and Technology Service, FIRO)

A new initiative being commenced by FAO is an investigation of Low Impact Fuel Efficient Fishing (LIFE). This project aims to look at ways of reducing the energy use in fishing through the use of proper operational techniques to reduce the amount of fuel consumed and the development of low impact alternative fishing gears. This is considered a global research priority for FAO over the next number of years.

8 Report from SGTCOD

The first meeting in the ICES Study Group on Turned 90° Codend Selectivity, focusing on Baltic Cod Selectivity (SGTCOD) was held on 23–24 May 2009 in Ancona, Italy. The Study Group chaired by Bent Herrmann and Waldemar Moderhak will run for three years. The meeting was hosted by Antonello Sala from CNR-ISMAR. The meeting was held just after the ICES WGFTFB 2009 meeting and was attended by 16 participants from 11 different nations.

One objective for the first meeting was to establish the group and to update all the participants on the objective for the work in SGTCOD. The final objectives for the three year run of the group work are as follow:

- Evaluate the effect of turning diamond netting by 90^0 (T90) on codend selectivity
- Improve knowledge of the size selection processes in T90 codends compared to T0 codends (normal direction of diamond netting)

- Attempt to quantify the magnitudes of the effects of different factors (construction, generic netting properties, stock specific morphology, catch composition)
- Develop a guide on T90 codend constructions with respect to size selection properties and optimal construction and
- Review available data on fish survival and in particular cod escaping from T90 codends

These objectives will be reached by combining field experiments, laboratory experiments with nettings, laboratory experiments with fish morphology specific on Baltic cod and theoretical approaches (structural mechanics and computer simulations). A case study on Baltic cod will be conducted. An important objective for the first meeting was to obtain an overview of experimental data and theoretical methods already available to help achieving the final objectives. A number of presentations were therefore given on experimental data or theoretical methods and results. Those presentations made it evident that a lot of selectivity data has been collected over the years and are available for the groups work. Underwater video recordings showing different codends and escape behaviour of Baltic Sea cod are also available. Together with applying the theoretical methods the data forms the basis for the future work in the group. But a systematic review of all the data available is needed. The group identified gaps in knowledge which did lead to the production of a relevant action plan. It was identified that specific data on morphology of Baltic Sea Cod would be beneficial. Some additional selectivity experiments would be necessary for a systematic assessment of the benefit on selectivity of turning codend netting by 90º with a similar T0 codend as baseline. Theoretical estimations of codend shapes for different amount of catches were to be carried out with the aim of theoretical estimation of the codend selectivity. It was agreed that assessing the shapes of different nettings in laboratory and analysing mesh shapes with respect to selective properties would help understanding and quantifying the basic selective properties of T90 compared to T0. Besides trials for Baltic Sea cod, a more general knowledge could be obtained by also proposing experimental and theoretical work to be carried out for other different types of fisheries.

On some specific points there are differences in opinion on the performance of T90 codends and on what is causing it between members in the SGTCOD group. But it is expected that these differences will help the group in producing a critical scientifically based evaluation according to the final objectives for the work of the group. Together the members of the group represent experiences and skills on the necessary scientific disciplines both experimentally and theoretically to enable the necessary work to be carried out. Members of the group also represent practical knowledge of the fishery in the Baltic Sea to ensure the case study for the Baltic Sea cod can be carried out in a relevant way.

9 Report from SGEM

The SG set out to examine the relationships between the physical vessel characteristics and the size of the gear towed by those vessels. Before doing this for specific fleets, the general issues surrounding appropriate vessel metrics was examined. This showed first that vessel power was strongly linked to both vessel tones and vessel bollard pull. For this reason vessel power, which was the most generally available metric, was used to define the vessel physical characteristics. It was also found that there were some changes over time in the ratio of power to length, with newer ves-

sels having relatively more power for their size. We also examined the possible choices in gear metrics, and focused on fishing circle (the circumference of the net opening) expected to be most important for white fish vessels, and groundgear length, expected to be most important for *Nephrops* vessels. We also developed the concept of "potential fishing power" where we compared the "capacity" of a vessel with its normal gear compared to the largest gear it was technically capable of pulling.

The SG examined five fisheries in detail, and the results are summarized below.

Scottish North Sea (IVa) demersal otter trawling for mixed whitefish

Firstly for single rig vessels:

- For vessels less than 1000Hp, there was a good positive relationship between vessel power and the fishing circle of the net towed.
- For vessels greater than 1000Hp, there was no relationship between vessel power and the fishing circle of the net towed.
- There were indications that the larger vessels could potentially increase the swept volume by at least 63% by towing larger nets
- There was no relationship between vessel power and the groundgear length of the net towed.
- There was some relationship between vessel power and stated towing speed, with larger vessels towing at higher speeds.

And for twin rig vessels:

- There was a relationship between vessel power and the fishing circle of the net towed, with larger vessels towing larger gears.
- There was no relationship between vessel power and the groundgear length of the net towed.

Irish Celtic Sea (VIIj,g) demersal otter trawling for mixed whitefish

Firstly for vessels towing "clean gear":

- There was a good positive relationship between vessel power and the fishing circle of the net towed.
- There was also a relationship between vessel power and the groundgear length of the net towed, not seen in Scottish whitefish vessels.
- There were indications that the larger vessels could potentially increase the swept volume by at least 63% by towing larger nets.

And for vessels towing rock-hopper gear:

- For vessels less than 1000Hp, there was a good positive relationship between vessel power and the fishing circle of the net towed.
- For vessels greater than 1000Hp, there was no relationship between vessel power and the fishing circle of the net towed. There was no relationship between vessel power and the groundgear length of the net towed. This was very similar to Scottish single rig vessels.

Scottish North Sea (IVa) demersal otter trawling for *Nephrops*

Firstly for single rig vessels:

- Vessels needed to be considered separately according to groundgear type; rock-hopper or "clean gear".
- There was no relationship between vessel power and the fishing circle of the net towed for either type of groundgear.
- There was no relationship between vessel power and the groundgear length of the net towed for either type of groundgear.

And for twin rig vessels:

- Vessels needed to be considered separately according to groundgear type; rock-hopper or "clean gear".
- There was no relationship between vessel power and the fishing circle of the net towed for either type of groundgear.
- There was a weak relationship between vessel power and the groundgear length of the net towed for vessels with "clean gear". There were too few rock-hopper equipped vessels to draw any conclusions.
- There was evidence that more powerful boats use higher towing speeds.
- There were indications that the "clean gear" vessels could potentially increase their fishing power by at least 30% by towing larger nets.

Irish Celtic Sea (VIIj,g) demersal otter trawling for mixed *Nephrops*

- There was a good relationship between vessel power and both fishing circle and the groundgear length of the net towed.

Pelagic trawling for mackerel

- There was no apparent link between power and size of mackerel nets towed by the Scottish fleet. There appeared to be two preferred sizes; ~1610m and ~1800m circumference. For the Irish fleet there was some relationship, with larger vessels towing larger gears. It was noted that the Scottish fleet is generally more modern, larger and more powerful than the Irish fleet, and this may explain the differences.

French gillnet fishery for hake

- As in the Scottish white fish fleet, there was evidence of a relationship between vessel size and size of gear for smaller vessels, but that this breaks down for the larger vessels.

10 Report from WGQAF

The Working Group on Quantifying All Fishing mortality (WGQAF) met in Copenhagen on 24 –26 November 2009 to address the following ToRs:

a) review recent research and development concerning unaccounted mortality in commercial fisheries including;
   i) Application of unaccounted mortality data to stock assessments.
   ii) Sources of data regarding IUU.
   iii) Potential for use of self (industry) sampling to account for discard mortality.
   iv) Review and report on ongoing work for mitigating unaccounted mortality associated with ghost fishing including consideration of best practices for reducing collateral mortality in fisheries;

v) Report on communication with, and guidance received from AMAWGC, WGFTFB, WGECO, assessment working groups, other ICES EGs, and organizations outside ICES.

Within these ToRs members agreed to:

- Continue to develop a better understanding of the needs of other EGs by reviewing all assessment WG reports, collating their findings to identify likely significant problems areas involving UM, and liaising direct with WG chairs through working documents as appropriate. Whist noting advice from WGECO on prioritizing species members agreed to focus on commercial species, particularly those subject to recovery plans and/or going through the ICES benchmarking process.
- Work with WGFTFB to organize and refine the programme for a workshop on best practice for survival experiments associated with currently unquantified fishing mortality to be held in Turkey during 2011. The main output of the workshop would be a multi-format manual describing all factors to be taken into account in devising, conducting and interpreting experimental work in this field.
- Consider and identify cost-effective methods and indicators for identifying "vulnerable species" (i.e. likely to have a high unaccounted mortality following encounters with fishing activities) and estimating the magnitude of likely sources of unaccounted mortality. Reflex inhibition was thought to be potentially the best type of indicator to use in assessing stress.
- Review information available about the 'trawl path mortality' of *Nephrops*.
- Review and start to quantify likely causes of cod mortality in VIa.
- Respond to a request from SGHERWAY to provide information on the impacts of catch slippage on herring.
- Track and assess progress in the use of CCTV for monitoring total catches and encourage other EG chairs to promote its adoption.
- Provide observations on the agreed text from the Coastal States in respect of managing NE Atlantic mackerel where this contained naïve or ambiguous provisions.
- Assess the need for a 'best practice guide' for static gear fisheries in order to minimize and mitigate the risks associated with gear loss and subsequent ghost fishing.
- Consider drafting a 'best practice guide' should be drafted for work on lost and abandoned fishing gears. This would aim to standardize terminology, data collection, data retrieval and experimental design.

11 Report from WKPULSE

Following the ICES Advice on Pulse Trawling on flatfish of 2006 further studies were carried out by IMARES, the Netherlands on catsharks (*Scyliorhinus canicula* L.), cod (*Gadus morhua* L.) and a range of benthic species (ragworm (*Nereis virens* L.), common prawn (*Palaemon serratus* L.), subtruncate surf clam (*Spisula subtruncata* L.), European green crab (*Carcinus maenas* L.), common starfish (*Asterias rubens* L.), and Atlantic razor clam (*Ensis directus* L.) under pulse stimulation of the Verburg-Holland system. These studies were reviewed and discussed at the meeting of the Workshop to Assess the Ecosystem Effects of Electric Pulse Trawls (WKPULSE). The reviewing experts

concluded that there is primarily more information needed on the effect on cod before the pulse trawl can be allowed on a commercial basis. The reviewing experts could not be convinced that the simulator provided an adequate representation of the in situ pulse, due to the fact that they were not able to review the specifications of the pulse characteristics resulting from confidentiality issues. They recommended that a three-dimensional temporal-spatial model of exposure of cod inside the trawl using information about behavioural responses validated by direct underwater observation would be useful. Furthermore it was suggested to investigate the effect of pulses on the electro-receptor organs of elasmobranchs, and determine the catch rates of these fish in beam trawls. Also to look at other gadoid species: e.g. haddock, and whiting. It was also suggested to investigate the effect of the pulse on the reproductive capabilities of benthos, but weigh this against the mortality in the conventional tickler chain beam trawl. In addition concerning enforceability and control it was noted that there are indications that the limits used in the present derogation that are deemed needed for fraud-resistant control (electrical power limited to 2.5 kW/m beam length, and amplitude to maximum 15 V) will not be sufficient to ensure that fishing efficiency with pulse trawls will not be raised in future, and it is recommended to investigate this aspect further and suggest limits that can. A presentation was also given about the development of a pulse trawl for the brown shrimp (Crangon crangon L.) fishery in Belgium. When both flatfish and shrimp trawling are considered pulse trawling will be an important issue for hundreds of fishing vessels in countries around the North Sea and the suggestion to set up an ICES Study Group on electrical fishing was mooted. See Section 6.1.2 for more detail)

12 Update on gillnet selectivity manual and WKGILLMAN

A Static Gear selectivity manual was first muted by WGFTFB in 1988. A number of drafts have since been completed. The most recent version has described procedures for gillnet selectivity but procedures for longlines and pot selectivity are not well developed and this has meant that the manual has not been completed. Given the increasing importance of all types of static gears and particularly pots it was felt important by WGFTFB that this manual is completed. In 2008 a WGFTFB topic group met to discuss and agree an Action Plan timetable for completion of the Manual. WGFTFB agreed a structure and time frame to complete the manual as well as identifying gaps in the knowledge and reviewing available literature pertaining to the measurement of the selectivity of all static gears. It had been planned to work by correspondence to complete the manual but this was not possible as a number of issues still need to be resolved and therefore a workshop to complete the substantive work required to complete the manual seemed the most appropriate form of action. This workshop WKGILLMAN was scheduled to take place in 2010 but due to a number of issues did not subsequently go ahead. Therefore the manual has still not been completed. The issue was discussed at WGFTFB in 2010 but no course of action was agreed.

13 ToR a): Incorporation of Fishing Technology Issues/Expertise into Management Advice

13.1 General Overview

This ToR was introduced at plenary by the chair and the background for the ToR was re-iterated. ICES is now asked to provide advice that is more holistic in nature, including information on the influence and effects of human activities on the marine

ecosystem. From the fishing technology perspective this includes information on how fishers are responding and adapting to changes in regulatory frameworks e.g. the introduction of effort control; technological creep; fleet adaptations to other issues e.g. fuel prices etc. In response to this WGFTFB initiated a ToR in 2005 to collect data and information that was appropriate to fisheries and ecosystem based advice. In 2006, the FAO-ICES WGFTFB was formally requested by the Advisory Committee on Fisheries Management (ACFM) to provide such information and to submit this to the appropriate Assessment Working Group. This type of information is becoming more and more important at both international and national levels. It demonstrates that the community of gear technologists have an important role to play in this and that our expertise is considered to be highly valued. Since 2009 this information has been included as an Annex to several stock assessment reports e.g. WGNSSK, WGCSE and WGHMM, although the issue of the appropriate timing for the provision of this information to the assessment working groups remains unresolved

13.2 Terms of Reference

WGFTFB should explore the means by which it can best provide appropriate information for Assessment Working Groups, ACOM and other management bodies such as GFCM in fishery and ecosystem based advice. This will include the information required for fisheries based forecasts, technological creep and changes in fishing practices, implementation of regulations and other fleet adaptations, ecosystem effects of fishing and potential mitigation measures. All areas for which ICES provide stock advice are considered.

13.3 General issues

As in previous years the conveners issued a questionnaire to the appropriate WGFTFB members in EU countries as well as Norway, Iceland, the Faroe Islands and also Turkey during February 2010 (see Annex 7). It contained a series of questions relating to recent changes within the fleets observed and also highlighting gear/fleet/fishery related issues that are important but are not currently recognized by Assessment WG's. Where possible, contributors were requested to quantify the information provided or state how the information has been derived e.g. common knowledge, personal observations, discussions with industry etc.

Specifically FTFB members were asked to comment under the following headings:

- Fleet Dynamics
- Technology Creep
- Technical Conservation Measures
- Ecosystem Effects
- Development of New Fisheries

Responses to the questionnaire were received from:

IMR, Norway	IMARES, Netherlands
SFIA, UK	FRS, UK-Scotland
IEO, Spain	Ifremer, France
BIM, Ireland	AZTI, Spain
ILVO, Belgium	CNR-ISMAR – Italy

The information provided was collated by the chair. The full information for individual ICES Expert Groups is given in Annex 7 but some of the general issues raised are summarized as follows:

Fleet Dynamics

As with 2009 the overall picture from the questionnaires is fairly negative for 2010. All countries have reported very low prices for fish and shellfish and there are indications that prices for some species have dropped by as much as 50% on 2007 levels. In the case of EU countries imports from third countries and the world recession are the main reasons given. Many vessels have tied up because of low fish prices during Q1 and Q2 of 2009.

Fuel prices have stabilized to some degree although in many countries, fuel is still a driving factor in their operational decision-making. In a number of countries effort e.g. Norwegian shrimp fisheries have declined in some fisheries due directly to fuel costs. In other countries fleets have altered their operational strategies to minimize fuel costs but also to access markets optimally.

As in 2009 the new EU Cod Recovery Plan covering a number of areas including the North Sea, West of Scotland, Irish Sea, Baltic Sea and Skagerrak/Kattegat as well as technical measures introduced into ICES Area VIa (West of Scotland) are still creating difficulties for fleets in a number of countries. There has been a continuation in the reported shifts in effort from areas without effort or less restricted by effort caps, from areas where the kw days allocated to vessels are felt inadequate.

There continues to be a move in France and Netherlands to convert to Danish seining instead of conventional trawling or beam trawling. These vessels are quite high powered compared to traditional seine net vessels and are using this power as well as sophisticate deck machinery to increase overall fishing time. A number of vessels entering this sector are being rigged as dual purpose vessels to take advantage of both seining and trawling opportunities.

There has been a large shift in the Irish fleet into on-board freezing of *Nephrops.* Approximately 22 vessels are now rigged for on-board freezing. This is mainly motivated by strong markets for frozen *Nephrops* as the traditional fresh markets for whole and tailed *Nephrops* still seems to be over supplied.

Decommissioning schemes are less in evidence with most Member States having suspended such schemes for the foreseeable future. Varying amounts of effort seemed to have been removed from the fleets involved but as reported last year there are indications in several countries that some of this effort is being reintroduced into fleets through purchasing of dormant licences. The impact of decommissioning therefore may not be as high as perhaps anticipated in terms of overall effort reductions. There is also some evidence of fleet renewal, particularly in the Scottish *Nephrops* fleet.

Specific changes to highlight the trends observed include the following:

- As in 2009 all countries have reported very low prices for fish and shellfish. Indications are that prices for some species have stayed at levels in excess of 50% of 2007 prices. In many countries vessels have tied up and most markets continue to be depressed. Imports are put forward by industry as the main reason. The one exception has been the market for frozen *Nephrops,* which had been depressed in 2009 has picked up significantly in 2010 with prices of up to €37/kg being recorded.

- Quite a number of Irish vessels are now equipped to freeze at sea and several more are in the process of installing freezing equipment. If every vessel which is planning to install equipment does so there will be approx 22 boats in the Irish fleet with the option of freezing. This will undoubtedly have implications for the *Nephrops* fisheries as most of these vessels are efficient 20m+ vessels fishing with twin-rig double codend trawls.
- Several of the larger Irish vessels (20–24m+) operating in Area VIa have been forced to move to Area VIIb-k due to a lack of days at sea. This is partially due to the reductions in effort required under the LTMP for cod becoming a limiting factor but also as a result of the allocation system being used in Ireland which gives a flat rate allocation to all vessels with a track record regardless of recent fishing activity. This shift of effort has put more pressure on Celtic Sea whitefish stocks.
- In ICES area VIa there has been a continuation of the trend to work in and around the "French line" as much as possible to maximize vessels days-at-sea allowance. This is most prevalent during winter and spring months when the monkfish fishery is at its peak. Another option to save days allocation in 2009 and 2010 has been for vessels to target Rockall which is outwith the days at sea regime.
- Scottish vessels traditionally targeting cod, haddock and whiting fish east of the French line have been severely affected by the 30% bycatch limits, which have effectively closed these fisheries. Trips in this area are no longer viable because of the lack of alternative economically viable species to make up the other 70% of catches. These vessels have either reverted to the North Sea or switched to *Nephrops* fisheries.
- The Scottish twin-trawl *Nephrops* fleet continued to re-new with six new larger powered vessels replacing older low powered vessels in 2009/2010. In addition the < 10m fleet sector (pots) there was 16 new boats replacing older vessels.
- Due to a combination of fuel costs, low fish prices and quota restrictions in Spain a number of larger operators are in financial difficulties. Despite strong political support, there are reports of commercial difficulties and numbers of skippers are leaving the industry. During 2009 six 40m freezer vessels were sold to Norway.
- A number of vessels in the French fleet there has been a shift from purse seining (tuna) and trawling (mixed demersal) to Danish Seining (Fly-dragging) in the Bay of Biscay in Area VIII. One purse-seiner in the period 2007- 2009 and 1 trawler in 2008, 3 other trawlers in 2009 and 6 new builds in 2010.
- In Belgium nine beam trawlers from the large segment (>300 HP) have been decommissioned, of these 2 have been 'partially decommissioned' replaced by two new gillnetters. By number, 10% has opted for decommissioning. This is 11% reduction of the total horsepower and 13% of the total GT of the Belgian fleet. Two new gillnetters have entered the fleet and one gillnetter/otter trawler.
- In the UK a geographical shifting of the under 10m fleet has been seen in the last couple of years as vessels (trawlers from the NE and Netters from the SW of England) that have historically worked from a single port have had to shift to other areas due to quota availability within the under 10m

pool. Target species have generally remained the same but movement to other areas have allowed the vessels to target species not currently available on their home grounds, i.e. *Nephrops* in the NE or have access to higher quota allocations by moving to an adjacent ICES rectangle. None of the changes reflect a change in the distribution patterns of fish it is all down to regulatory pressures and quota availability within the under 10m pool.

- Also in the SW England fleet, there are fewer under 10m "rule beaters" working pressure stocks as they have either left the industry or diversified to other sectors. The number of beamers has also steadily declined. A decommissioning scheme for the under 10m vessels during 2008 affected a cross section of the fleet taking out both new and older vessel. A rough estimate of the proportion of the fleet decommissioned would be 2–3%. Of the vessels that decommissioned at least half of these owners have since bought another under 10m vessel and re-entered the fishery.
- The Closed season for the Gulf of Cadiz Otter trawl fleet fishery has been increased to 90 days, in two periods: 60 days from mid-September to mid-November and 30 days from mid-January to mid February. The increased biomass of fish stocks resulting from this closure is shifting effort into coastal resources, thereby saving energy and homogenization of landings. It has been noted an increasing trend in the abundance of white shrimp (*Parapenaeus longirostris*) and effort has been shifted away from *Nephrops* onto this species.
- The Basque pair trawl fleet targeting hake have made shorter trips than usual recently, due to a low market price. Shorter fishing trips improved the fish freshness. Also vessels have coordinated entry into base ports sequentially during the week, avoiding landing all catches in the same traditional two days of the week (Monday-Thursday). In this way, fish auctions take place throughout the week which should raise the market price of the catch.
- During 2009, five single trawlers have been decommissioned (20% of the Basque trawler fleet). Two of these trawlers were 10 years old. One second hand vessel (single bottom trawler) has been bought from Galicia in 2010.
- In the English Channel and North Sea: 8 French vessels (~4%) have been decommissioned by end of 2009. Two were fishing for Saithe (more than 30 years old - (area IV); one was a gillnetter (28 years old – area VIId); five were trawlers (20 to 26 years old – IV and VIId).
- Several larger French trawlers using mesh size range 70–99mm have continued to fish further north in the North sea (southeast of Scotland in Area IVb) because of the low abundance of whiting in VIId, and also to reduce fuel consumption by increasing the duration of their individual trip (from 2 days long to 4 or 5 days long).
- The gradual shift from beam trawling for flatfish to twin trawling and fly-shooting (Danish seining) on other species e.g. gurnards, and *Nephrops*, etc. in the Dutch fleet is continuing. However, two vessels engaged in outrigging reverted to conventional beam trawling to catch their sole quota when plaice prices were too low. They may take up outrigging again depending on economics and quota.

- According to the Dutch industry fuel costs are still high and income is under pressure. Of all the main fish species including sole, plaice, cod, turbot and brill, more is being landed (all fish +6%). The number of landed shrimps appears to be 20% higher in 2009, while *Nephrops* landings have stayed steady in 2008. The prices of all fish types were lower than 2008 on average by approximately 16%. The average price of sole tends towards € 9.50 per kg, € 0.50 lower than in 2008. In particular the price of plaice has fallen steeply. It is expected that the average price will not be over €1.40 per kg, a reduction of at least 30%. The price of shrimps was also very low in 2008. Over the whole year, at least a 30% lower price is expected, around 2.70 € per kg, so around € 0.34 less than the estimated cost price for shrimp cutters. The price of crayfish will be at least 25% lower at around € 4 per kg.
- The total engine power for the entire Dutch fishing fleet declined significantly to 429,000 hp (-8%), mainly due to the decline in the number of (big) cutters and despite the inclusion of the other small high seas fishing vessels (described below).The cutter (beam trawler) fleet itself declined by 37 vessels (-11%) to 308 vessels. The average engine power per vessel declined by 8% to 779 hp. The total engine power used of this fleet went down to 268000 hp, a fall of 10%.
- The Dutch Ministry in collaboration with the Dutch Fish Product Board have limited the maximum engine power of Dutch fly-shooters and twin-riggers to 500 and 700 kW respectively from 2011.
- In Belgium nine beam trawlers from the large segment (>300 HP) have been decommissioned, of these 2 have been 'partially decommissioned' replaced by two new gillnetters. By number, 10% has opted for decommissioning. This is 11% reduction of the total horsepower and 13% of the total GT of the Belgian fleet. Two new gillnetters have entered the fleet and one gillnetter/otter trawler.
- Up to 30 Northern Irish vessels shifted from the Irish Sea to the North Sea in Q1 of 2010 due to better fishing opportunities. Due to a lack of quota, however, discarding of whitefish by these vessels has been high.
- In the Basque artisanal fleet fishing for tuna (trolling lines) and mackerel (handlines) all year, effort was restricted to 8–9 months in 2009 (about 3–4 month mackerel and 4–5 months tuna). Vessels stay in port for the rest of the year. The reduction of mackerel quota has restricted the fishery to 1–2 months and some boats have started fishing with other gears (longlines, gillnets) to supplement their fishing activities.
- Daily or weekly quotas (depending on the fishery) introduced by the fishers in the Basque mackerel fishery (handliners and purse-seiners) and in anchovy (purse-seiners). This can be considered like a market strategy trying to improve prices.
- There has been continued decline in fishing effort and total catch in the shrimp fisheries in the Barents Sea. Increased fuel cost is a driving force for the decline in shrimp trawl fisheries.

Technology Creep

The effects of technological creep are still evident in many fisheries as observed in 2006, 2007, 2008 and 2009 with the main focus on fuel efficiency measures. In Norway

there have been continuing attempts to use pelagic gears for targeting demersal species such as saithe and cod, while in several countries there has been experimentation in demersal fisheries with trawl doors that fish "off-bottom". This is mainly driven by reducing fuel consumption but potentially has added environmental impact advantages over traditional trawl doors. In the Netherlands and Belgium there has been high uptake of new fuel efficient beam trawl designs (e.g. SumWing), which have been extensively tested and shown to be give fuel savings as well as increased fishing time.

As in previous years there have been a number of developments in gear design to reduce drag including the use of low drag netting in both pelagic and demersal fisheries. In Italy there has been adoption of twin-rigging instead of traditional single-rig trawls. This particular move has created concern among the Italian authorities given the improved efficiency of this method. There is also increased use of 3D mapping sonar systems in a number of countries (UK, France, Belgium, Netherlands) as fishers try to open up new areas.

Specific examples of technological creep are given below:

- In the last 3–4 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishers: "Rete gemella"). The main characteristic of the twin-rig are four-panel trawls with small or large lateral panels (named Americana trawl, in Italian). These nets also have large meshes in the wing section and are manufactured in Raschel knotless-PA and knotted-PE netting. The nets are designed to have increased vertical and horizontal openings are thought to be highly efficient. There is a big concern, though from fishers using traditional bottom trawl about the impact of these twin trawls on the bottom. The situation is being monitored carefully in Italy and as precautionary approach the bottom trawlers converting to twin trawls are obliged to operate one day per week less than the traditional trawlers.
- In 2009 a semi-pelagic trawl technique for saithe was successfully developed and introduced in the Norwegian fishery. The most successful trawl is designed with hexagonal front part meshes and rigged with pelagic trawls off bottom. Better efficiency, less fuel consumption and reduced bottom impact are reported, but presently not quantified.
- Rigging of trawl doors off-bottom is becoming increasingly common among several traditional bottom-trawl fisheries in Norway (Trawling for Saithe, Norway Pout and Sandeel are included).
- There have been a number of initiatives taken in France to improve fuel efficiency these include: new optimized doors, which fish "off-bottom"; optimized shaping of the trawls, increasing meshes when possible in the aft part of the trawls and using low drag materials such as Dyneema and Breizline twines; and also decreasing speed in transit and fishing (for example keeping a constant pressure of the turbo when fishing, without considering the speed over the ground); and also avoiding transiting against the tide/current where possible.
- Up to 50 Belgium (10–15) and Dutch (35–40) beam trawlers have switched from conventional beam trawls to SumWings. This might have some effect on fishing grounds chosen, and effort by time gains in shooting and hauling gears. In addition gear can be towed faster with the lower gear drag. The catching performance of SumWings has been compared with conven-

tional tickler chain beam trawls. No major differences were found, when ticklers chains are kept the same. Some skippers report that they can haul in faster due to lower gear drag and achieve an additional 2 hauls per week trip. Other say they can fish in areas where difficulties arose with the conventional beam trawls, and that gear fasteners occurred to a lesser extent. The SumWing technology is still to be adapted to fishing in very uneven grounds (sandy peaks) in the southern North Sea. New wing designs were produced in early 2010. Examples are the so-called 'JackWing'.

- As in last 2009 more and more Belgium and Dutch beam trawlers are equipped with 3D mapping sonar which has opened up new areas to fishing (close to wrecks). (Belgium and Netherlands: Implications Opening up of new grounds).

Technical Conservation Measures

One particular issue that has arisen is the introduction of the OMEGA mesh gauge. The industries in a number of countries have reported problems with the implementation of this new mesh gauge. It is claimed that this gauge gives measurements of ~5%-10% less than the wedge gauge previously used by fisheries inspectors. The industry claims the introduction of this gauge is effectively an increase in mesh size and also that fishers have been forced to replace codends which prior to the new regulations were perfectly legal. Similarly netmakers have been forced to dump netting as it is no longer legal. In Scotland skippers have replaced codends constructed from mesh sizes which are 8mm to 10mm greater than pre-Omega gauge introduction effectively increasing codend selectivity.

In a number of fisheries as in previous years research into selective gears has been extensive but still with only limited uptake. The drivers for uptake are still clearly regulatory, i.e. as a means of attaining an increased quota entitlement or increased access; or economic through higher price paid for a responsibly caught product.

Specific examples illustrating the development and uptake of selective gears are given as follows:

- A combined grid device that releases undersized fish and small shrimp is being developed in Norway and is being used voluntary by some vessels fishing shrimp in the Oslofjord.
- The French have been carrying out trials in the Channel and North Sea looking at the effect on whiting discards from using a 120 mm square mesh panel positioned at 6 metres from the codline. The results seem positive. In addition there are ongoing trials with flexible grids combined to cod selective devices and also large mesh "eliminator" style trawls. The data from this work has not yet been fully analysed but is encouraging.
- The use of sorting grids in trawl fisheries for Norway pout and Blue Whiting in the North Sea has become mandatory in the Norwegian sector in 2010.
- The UK Conservation Credits Scheme made available options to buy back additional days at sea for both TR1 and TR2 vessels that adopted the exclusive use of selective gears in the Scheme years 2009/10 and 2010/11 in both West of Scotland (WoS) and the North Sea (NS). The table below sets out the incentives offered for both Nephrops and whitefish gears targeting NS and WoS grounds. Uptake of selective gear buy backs under CCS in

2009/10 was modest (1). Uptake has increased so far in 2010/11 fishing year as effort restriction impact on vessels. So far (May 2010) 20 TR1 NS vessels using Orkney Trawl, 20 TR2 NS vessels using 120mm SMP and 7 TR1 NS vessels using 130mm codend.

- Eight different selective gear designs have been compared successively to a standard commercial trawl In the mixed Hake-*Nephrops* fishery of the Bay of Biscay by Ifremer in France during spring 2009: 2 square mesh cylinders (62 and 70mm), a combination of grid and square mesh panels, 2 settings of Radial Escape Sections (RES), and 3 rig designs to force the mesh opening (2 settings of 75% hanging ratio and T90). All devices have been observed with underwater video systems. The catch comparison analysis for the square mesh cylinder showed a good escape rate for juvenile hake with a relatively low loss of *Nephrops*, either below or above MLS. The grid and square mesh panels combination was efficient at releasing both, juvenile of *Nephrops* and hake with low escapement of commercial individuals. The escapement rate with the RES was highly dependent and sensitive on its setting. The opening mesh designs appeared to be non-adapted to the mixed fishery with a very high escape of commercial *Nephrops*.
- In the SW England fleet there has been a move among different types of vessels to use bigger mesh in top panels of the gear as well the use of larger mesh square mesh panels (~100–120mm). There are also now 15 vessels (beam trawlers) on the south coast using square mesh codends to reduce discarding.
- Recognition through initiatives such as "Project 50%" (See 18.1.3) on beam trawlers and trawlers in the SW of England using skippers' ideas in ways to reduce discards have been quite successful. Methods adopted have included the use of larger mesh in both the top sheet and belly, benthic panels and square mesh. The incentive for fishers where that gear was made available to the skippers own specifications and also improved public perception of their operations.
- Under national legislation there has been an increase in the mesh size from 40 mm to 55 mm in the Gulf of Cadiz Bottom Otter Trawl Fishery.
- Three Irish vessels (~20m/350kw) are now using the "Swedish" sorting grid in the *Nephrops* fisheries in the Irish Sea (Area VIIa). Based on a case submitted by the Irish government these vessels are now exempt from effort restrictions currently in force in this area. The observations carried out showed cod catches with the grid to be consistently less than 0.1% per trip. It is hoped other vessels will follow.
- In addition to the 3 Irish vessels using grids, 6 other Irish vessels are using the inclined separator panel in the Irish Sea. Under the current effort management plan in place these vessels are receiving additional days over and above other vessels. The fish catches from these vessels are being closely monitored to ensure that the separator panel is not being circumvented which can be easily done by lacing up the escape hole at the top of the panel.
- Several Irish trawlers who are freezing *Nephrops* on board are using 120mm square mesh panels in their trawls when fishing on the Porcupine grounds. These vessels report high concentrations of argentine, boarfish and blue whiting on the grounds that are of no commercial value.

- Irish vessels operating inside the restricted area in Area VIa, particularly on the Stanton Bank grounds have reported that the 120mm codend mesh size required in this area is causing a large quantity of their legal megrim catch to be damaged due to gilling. This has also been reported by Scottish fishers. This makes this fishery uneconomic and the fishers have asked for a review of this regulation in light of low cod catches in this area (one vessel landed 120kg cod from 96 tows).

Ecosystem Effects

The main ecosystem effect noted has been discarding in a variety of fisheries. Discarding of cod, haddock and hake in the West of Scotland and Celtic Sea are among the worst cases reported and discarding in this instance seems to be driven by quotas being very restrictive in Q3 and Q4 of the year as fishers strive to stay within regulations but also by low prices for smaller grade fish.

Specific examples of discarding reported include:

- In VIa in 2010 Scottish vessels have reported poor monkfish catches and many areas seem to show unusually large numbers of Lesser Spotted Dogfish (*Scyliorhinus Canicula*) and Red (*Aspitrigla cuculus*) and Grey Gurnard (*Eutrigla gurnardus*). All Common Skate (Blue Skate, *Raja batis*) are now being discarded. There remains a tendency to "high grade" for species such as cod and hake as continued low quota and poor prices make it financially unattractive to land the smaller sizes. In addition to this unstable megrim prices in 2010, have also seen vessels discarding bruised megrim.
- There is widespread reporting of discarding of juvenile haddock in the Celtic Sea. Irish fishers have reported haddock in the size range from 20–23cm to be abundant on grounds on the south coast leading to widespread discarding.
- Irish and UK inshore vessels have reported spurdog to be plentiful in Area VIa and VIIb in 2009 and 2010 contrary to scientific advice. Due to a zero quota for this species, however, they are forced to discard this species.

On a more positive note improvements in stocks have been noted in several areas. In particular hake and megrim in the Celtic Sea and West of Scotland have been reported as being abundant.

- Irish vessels operating in VIa both inside and outside the restricted area (French Line) have reported very good signs of megrim and hake. They report catches at levels not seen since the 1990s. Catches seem to have increased along the shelf edge for these two species. Similarly 4–5 Irish gillnetters still in operation have enjoyed very good fishing for hake between 70 and 100 miles SW of the Mizen. Prices are poor but the large volumes (300–400 boxes for four hauls) are compensating for the bad price.
- Irish vessels fishing at Rockall (VIb) in Q1 and Q2 of 2010 report that haddock catches have reduced by 30–40% on previous years. There seems to be a scarcity of small haddock on the grounds and the vessels also report no Russian activity in international waters as in previous years. However, the vessels are reporting good signs of cod in the area, as well increased catches of monkfish and megrim.

A number of gear modifications have been tested and in some cases are being used to reduce the bottom impact of towed gears. A number of initiatives have been intro-

duced to the Dutch and Belgium beam trawl fleets to reduce the catch of benthos as reported in 2009 and these are being used on a voluntary basis in many cases. As reported under Technical Creep there has also been considerable testing of trawl doors rigged to fish off-bottom, as well as targeting gadoids with pelagic gears. While this is primarily driven by fuel prices, both initiatives potentially have benefits in respect of reduced bottom impact.

Specific examples include the following:

- Two Dutch vessels (TX68 and TX36) are using the pulse trawl under derogation but on a commercial basis. One vessels is using the pulse trawl and sum wing together. Results are promising and fuel savings up to 60% were achieved with good earnings. The system has shown to reduce catches of benthos by 50–70%, and likely reduce direct mortality of benthic invertebrates in the trawl path, 24% for the pulse trawl vs. 36% based on 15 taxa. Attempts are still being made by the Dutch ministry to enable allowance of pulse trawling in the new European TCM regulation.
- Dutch beam trawlers are continuing to voluntarily use longitudinal release holes in the lower panel of the trawl, which open when nets are filled with benthos. This work was continued in 2009 but the industry felt that more research was needed over a longer period and also on commercial boats to further develop and fine-tune the techniques.
- Belgium beam trawlers are continuing to voluntary use "alternative" beam trawl, i.e. beam trawl with technical modifications (T90-codend, Benthos Release Panel, big meshes in the top panel). The initiative has been continuing since 2008. A better size and species selectivity is expected, as well as a discard reduction of benthic invertebrates. In addition the increasing use of the SumWing is supposed to reduce the impact on the seabed.

There are a few reports in 2010 of suspected bycatch of protected species including cetaceans, sea turtles and seabirds. Testing of acoustic deterrent devices is continuing in a number of fisheries. Predation by seals has been reported as continuing problems in Ireland in gillnet fisheries. This problem has been reported for a number of years and seems acute. Specific instances of fisheries interactions with protected species and associated mitigation measures include the following:

- There continues to be a reported cetacean bycatch in the French sea bass and Albacore tuna pair pelagic fisheries. This bycatch has reduced from peak levels but nonetheless still exists. Trials with a range of acoustic deterrent devices are continuing.
- There has been a reduction in turtle bycatch in the French Guyana shrimp fisheries due to full implementation of TEDs on the vessels involved in the fishery.
- There is a suspected bycatch of harbour porpoise (*Phocoena phocoena* L.) in the Dutch gillnet fishery based on recent strandings. Autopsies showed that a number of deaths were likely fishery related.
- There is a suspected bycatch of cormorants and other diving birds in the Belgium gillnet fishery but the frequency with which it effectively happens is reportedly very low.
- Predation of fish catches by mainly Grey seals form gillnet/tangle net fisheries continues to become a problem on all coasts of Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high.

Seals have been reported up to 80–90 miles off the coast. More than 30 vessels in the size range 10–20m are affected by this phenomenon. One vessel operating in Area VIa has reported that seals are not only targeting gillnets but also vessels jigging around wrecks and rough ground for white Pollack

- An unusual phenomenon has been noted in Ireland where a number of fishers have reported very high levels of Anisakis worms being found in hake in the last 6–8 months. Counts as high as 17 per kg have been reported and this has resulted in a much lower price for hake. Changes to handling practices including holding the fish in slush ice prior to gutting and also gutting immediately on landing on deck have been tried to reduce the problem. The reasons for it are unknown.

Development of New Fisheries

Several new fisheries have been reported in 2010. Two are pelagic fisheries of which one is on an experimental basis in international waters and the other is a small-scale pelagic fishery for anchovy off the southwest coast of the UK. There is also continued experimentation of static gears as a means for targeting fish although the indications are that these fisheries are still not economically viable in most cases. There is one example of a dive fishery for scallop developed in France.

Examples of new fisheries are reported as follows:

- One Belgium otter trawler is targeting squid in area VIId as an alternative for winter. Several Belgian netters have carried out trials with gillnets for turbot, cuttlefish pots and fish traps, experiments were partially successful and will continue in 2010.
- One 59m Irish RSW pelagic vessel has been chartered by a Chinese Company to carry out research on Peruvian squid and giant squid in the South Pacific. The Chinese company is endeavouring to develop a new fishery in international waters.
- The French scallop industry is attempting to develop dive fishing for scallops in Northern Brittany. Five vessels used to prosecute a fishery for abalone by diving and have managed to obtain licences to dive for scallop in 2008 in the Rance River. In 2010, they have also been allowed to fish scallop in one area near Saint Malo. The legislation that applies to these vessels is almost the same than as for scallops dredging in terms of catch and effort limitations. In another area in Northern Brittany (area open only 15 days per year), fishers that received licences to dredge for scallop can also choose to dive for them instead. Uptake has been restricted to one vessel to date.
- One Belgium otter trawler is targeting squid in area VIId as an alternative for winter. Several Belgian netters have carried out trials with gillnets for turbot, cuttlefish pots and fishtraps, experiments were partially successful and will continue in 2010.
- An anchovy fishery has developed in the SW of England and a number of vessels looking to target the species when available. A proportion of these vessels tend to be multi-purpose netters or trawlers. The fishery tends to be a winter one and closer to the shore than they would normally work, so displacement from there standard fisheries can be seen as minimal.

13.4 Information for individual assessment working groups

Specific information relating to different areas and fisheries to be provided to Assessment Working Groups and other Expert Groups are detailed in Annex 7. Information is provided for the following WG's:

WGCSE	WGHMM
WGNSSK	AFWG
NWWG	WGWIDE
HAWG	WGNEW
WGANSA	WGECO
WGMME	WGSE
SGBYC	GFCM

No information was supplied by any of the Baltic countries.

13.5 Conclusions

1) WGFTFB concluded that it was worthwhile for the group to continue to collate this information on an annual basis subject to further revision of the questionnaire and better quantification of the information where possible.

2) WGFTFB concluded that it would be worthwhile to liaise with the RACS, as the North Sea RAC at the very least is already collecting similar information.

3) WGFTFB recommended that a timetable for provision of this information to the Assessment Working Groups be drawn up with ACOM and the assessment chairs that better reflects the timing of the individual working groups and the assessment process. WGFTFB further recommends that ACOM consider whether this information would be better collated at the Benchmark Workshops.

14 ToR b): Seine net fisheries

14.1 General Overview

The fishing method of seining is reputed to have first been carried out by a Danish fisher, Jens Laursen Vaever, in 1848. This method of seining, known as anchor seining, is still carried on in Denmark and other countries today. In the early 1920s Scottish fishers developed a different method of seining which dispensed with the need for an anchored dhan, but which utilized the thrust of the vessel's propeller to balance the drag of the gear as it was slowly winched aboard. Over the years fly-dragging or Scottish seining, as the method came to be known, has firmly established itself as an important method of capture used by demersal fleets in a number of countries.

Seining, either fly-dragging or anchor seining, are considered to be "environmentally friendly" fishing methods with a number of positive benefits. Traditionally the gear used tended to be of much lighter construction and as there are no trawl doors or warps, results in less impact on the seabed than trawling. The use of such light gear also means the method is very fuel efficient. Another positive aspect of the method is that fish are only caught in the very last part of the capture process, and therefore are

not in the codend of the net very long leading to high catch quality of fish compared to trawled fish.

In recent years the fuel prices have steadily increased and attention has once again shifted to this method of fishing. There has been a switch back to this method in some countries e.g. Scotland and Ireland and interest in developing the technique in other EU countries, notably France and Netherlands and further afield in countries such as the Philippines and South Africa. While there is no doubting the positive benefits of seining as indicated, concerns have been expressed that there are negative aspects associated with the method that should be addressed, given the increased interest and adoption by fishers globally.

A WGFTFB Topic Group was formed to address this ToR. This Topic Group first met at the 2009 WGFTFB meeting. At this meeting an outline of a comprehensive report on all aspects of seining was drawn up and authors assigned to these chapters. It was clear from the start that this work could not be finished within one meeting. Therefore during 2009 the participants focused their attention on the first two Terms of Reference and produced a draft report for the WGFTFB 2009 report (ICES, 2009).

At WGFTFB 2010, the topic group met from the 2 - 4 June to revise the 2009 report based on new information, address the remaining ToR's on selectivity, conduct final editing, and clarify the recommendations given. The final report detailed in the following section contains all of the 2009 and 2010 text combined for completeness.

14.2 Terms of Reference

A WGFTFB topic group of experts was assembled to address the following terms of reference:

1) Identify all seine net fisheries globally and describe the gears being used in terms of net design, rope material and construction, as well as areas being worked.

2) Critically assess these fisheries, identifying the positive aspects in terms of reduced fuel consumption, high fish quality and low bottom impact, as well as any negative aspects with respect to gear selectivity and technological creep.

3) Evaluate methods for determining selectivity in these gears to allow comparison with conventional towed gears e.g. otter trawls.

4) Make recommendations for research/monitoring work to substantiate (or otherwise) claims for environmental friendliness, discarding etc.

14.3 List of Participants

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14.4 General issues

14.4.1 Identification of seine net fisheries

The Topic group attempted to identify all seine net fisheries globally and describe the characteristics of the gears and methods, as well as operational differences between countries. Table 3 below summaries the findings of this initial review by country as updated in 2010.

Table 3. Description of Seine Net Fisheries Globally (Fly-dragging and Anchor Seining).

Country	Area	No. Of Vessels	Average Hp/Length	Type of Seine e.g. Anchor (Danish)/Scottish/Pair Seine	Target Species
Ireland	Celtic Sea and Irish Sea	6 (2010)	23 m / 555 hp	Fly dragging (Scottish seining)	Haddock, Whiting, Cod, Hake
France	Celtic Sea, English Channel, North Sea, Bay of Biscay	5 (2009 and 2010) (plus 4 under construction)	18–35 m / 500–1000 hp	Fly dragging (Scottish seining) And mixed trawl/fly dragging	Red Mullet, Squid, Whiting, Cod, Hake, Seabass, flatfish
Iceland	Icelandic waters	67 (2008)	22 m / 457 hp	Fly dragging (Scottish seining)	Plaice, Dab, Lemon Sole, Cod, Haddock
Norway	Barents Sea, North Sea	150 (2008)	12–40 m / 100–2000 hp	Tow dragging (similar to Japanese method); Fly dragging (limited to small areas)	Cod, Haddock, Saith, Greenland Halibut, Plaice
Netherlands	North Sea, English Channel, Bat of Biscay	10 (2–3 under construction)	24–40m / 500 - 1500 hp	Fly dragging (Scottish seining)	Red Mullet, Gurnard, Squid, Whiting, Cod
Scotland	North Sea, West of Scotland	20 (single)	21 m / 620 hp (single)	Fly dragging (Scottish seining)	Mainly cod, Haddock & Whiting, also saithe, hake & flatfish
		40 (pair seine)	24 m / 750 hp (pair)	Pair seining	
Australia	Lake Entrances, Victoria & eastern Bass Strait	19 (2004)	Not specified	Fly dragging	Flathead & whiting
Denmark	North Sea, Baltic, Skagerrak & Kattegat	51 Danish Seiners; 5 Scottish Seines; 2 Dual purpose	11–20m Danish Seines 12m-31m Scottish Seines 20–24m Dual Purpose	Fly dragging (Scottish seining); Anchor seining (Danish anchor seining; older vessels)	Plaice, Cod
Sweden	Skagerrak & Kattegat	2	Not specified	Fly dragging	Cod and flatfish
Canada	Gulf Maritimes & Newfoundland Gulf Maritimes & Gulf Quebec	18 (2009) 11 (2009)	10–20m 10–30m	Fly-dragging Fly-dragging	Greysole, American plaice, cod
New Zealand	Haruaki Gulf, Bay of Plenty & East Northland	25 (up to 100 historically)	12–24m	Fly dragging	Snapper, John Dory, red guranard
Japan	West of Japan Sea	~48	> 15m	Fly-dragging	Snow crab, Falhead flounder
Faroe Islands	Icelandic waters & Faroese plateau	1 (15 vessels historically 1940s-1950s)	24m-30m	Fly-dragging	Cod, Haddock , Saithe
Phillipines	Visayan Sea	183 vessels (2007)	18GT	Fly-dragging (small vessels)	Mainly pelagic species

There are a number of seine net techniques used around the world as well as several novel techniques and although there is a huge amount of variation with respect to net design, seine rope weight and lengths used most seine net operations can be categorized under four headings as follows:

- Anchor seining (Danish seine)
- Fly-dragging (Scottish seining)
- Pair seining
- Other novel methods of seining

Purse seining is not discussed under this term of reference.

14.4.2 Fly-dragging (Scottish seining)

Fly dragging or Scottish seining (as illustrated in Figure 4) is well described by Galbraith and Rice (2004) and is only carried out in daylight. This fishing method depends on using long lengths of rope (or coils) up to 3.5 kilometres a side, to herd fish into the path of a net as the gear is hauled back slowly. When the fishing ground has been located, a dhan, marked with flag and radar reflector, is attached to the free end of the first rope and dropped over the side. The vessel then sets a course away from the dhan paying out rope as it steams. With typically 2 to 3 coils of rope remaining the boat alters course, still paying out ropes, and steams across to shoot the net. When the net and bridles have been shot in a straight line the vessel starts to pay out the second length of rope, shooting another 2 to 3 coils before altering course again to head back to the dhan to complete paying out remaining rope coils. By the time the gear is set, the dhan picked up and the end of the first rope retrieved, nearly all the length of rope each side is lying on the seabed. With the vessel maintaining just sufficient way to be going ahead, both ropes are hauled simultaneously, slowly at first, the ropes herding fish towards the path of the net as they close. As hauling proceeds the net slowly picks up speed and begins to move in the direction of tow. Gradually winch hauling speed is increased and the net begins to chivvy fish just in front of it while the ropes continue to herd more fish inwards. When the ropes are seen to be nearly parallel they are hauled at high speed and the net overtakes the remaining fish in its path. Hauling at this speed continues until the Danlenos are brought to the ship's stern, thereafter the net is hauled and the codend emptied. The track the vessel follows when shooting will normally take up a triangular shape. However, there are several alternatives to this procedure for example most common is to increase the swept-area by not heading directly back to the dhan but continue heading away from the net, After the last rope coil is paid out the vessel tows on the rope towards the dhan. Seine net tow duration depends on the number of rope coils being shot but the hauling process can take up to 2 hours to complete.

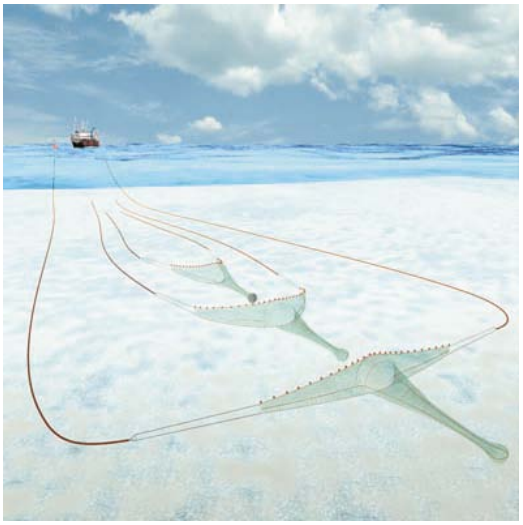

Figure 4. Fly-dragging (Scottish seining), taken from Galbraith and Rice (2004). © Crown copyright. Reproduced with the permission of Marine Scotland.

14.4.3 Anchor Seining (Danish Seining)

"Anchor seining" (as illustrated in Figure 5), evolved in Denmark and is the original seine netting technique from which "fly dragging" described above was a later development. As described by Sainsbury (1996), basically, the operation does not defer so much from fly dragging except that the marker buoy is anchored while hauling, and the warps and net are hauled entirely by winch. The main difference between the two methods is the markedly reduced power required by anchor seiners. This is reflected by the low fuel consumption by vessels engaged in this fishery. Also anchor seiners use longer rope lengths, up to 4840m, thereby reducing the difference in swept-area between fly-draggers and anchor seiners.

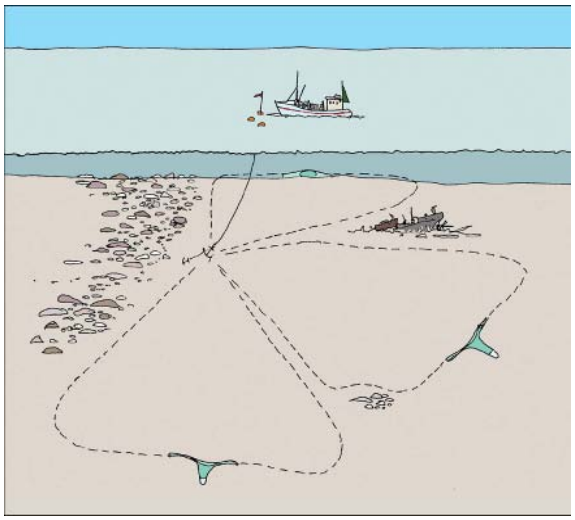

Figure 5. Danish Anchor seining with an anchor enables you to make several sets out of the same anchor position and depends on the prevailing tidal currents

14.4.4 Pair Seine

Pair seining (as illustrated in Figure 6) is a technique that developed in Scotland as a more efficient and simpler method than traditional single boat seining (Galbraith and Rice (2004). The main advantage of this development was that it substantially in-

creased the area of seabed swept by the gear and significantly improved catches when fish concentrations were small and widely dispersed. Originally the shooting technique for this method was the same as described above for fly-dragging. However, instead of the vessel deploying the gear returning to the dhan it was picked up by a second vessel. Both vessels then towed the gear, maintaining a distance of up to 0.5 nautical miles apart, in the same manner as a demersal pair trawl for up to 4 to 5 hours. At the end of the haul the vessels would come back together and the end of the rope passed back from the second vessel and the gear hauled at high speed as per single seining. However, recently a further development has occurred where the gear is no longer deployed as per single seining but exclusively as demersal pair trawl. Therefore it could be argued that Scottish pair seining should no longer be considered a seining technique as it has become so similar to demersal trawling.

Figure 6. Towing the pair seine demonstrating its similarity to demersal pair trawl. © Crown copyright. Reproduced with the permission of Marine Scotland.

14.4.5 Other Seine Net Methods

While not of direct relevance to this term of reference it is worth noting that there are a number of other different seine netting techniques used globally. Seine net with and without bags i.e. a section to retain the catch are used widely in freshwater fisheries as reported by Otto and von Brandt (2005). Generally in freshwater fisheries, seines are set from two boats and hauled from a fixed place on the shore or from an anchored boat. Otto and von Brandt (2005) also reports of seines being operated in freshwater by fishers wading into the shallow water, or in the form of beach-seines, with one man on a raft or boat rowing along the shore and another man walking along on shore at the same time. In some South American countries horses are used to haul the gear. Freshwater seines are often criticized for being unselective.

In addition to seines used in freshwater fisheries, beach seining, which is a very old fishing method, is still used extensively in marine fisheries some parts of the world, notably Australia. Beach seines are usually set by means of a single boat with one wing of the seine remaining fastened to the beach, while the other wing, the net bag then the other wing with its drag line are shot in a wide arc then brought back to the beach and hauled either mechanically or by hand. Beach seines differ very much in size and construction. There are historical reports in New Zealand of beach-seines of more than a mile in length, requiring 500 people to haul them (Phillips, 1966).

One very special method of seine fishing is that used below ice in northern Nordic countries as described by Turunen *et al.* (1997) for targeting species such as vendace. The under-ice winter seining is made as follows as shown in Figure 7: holes in the ice (thickness usually 40–60 cm> are made with chainsaw and motorized drills). Hauling ropes are drawn under the ice by a rope-steered, battery powered device. This buoyant apparatus is equipped with two wheels with sharp pins which firmly bit on the undersurface of the ice. Hauling ropes are then attached to the floating spreaders fixed to the wingtips of the seine. With the assistance of sharp skates, the spreaders slide under the ice during the haul. The special mechanism of the spreaders forces the seine to form a typical sphere during the haul. The seine ropes are reeled in by the small motorized (combustion engine) winches fixed behind the heaving hole. With the help of this new technique only two men (instead of 4–6) are now needed to operate a winter-seine. Two or even three hauls can be carried out during a short winter day.

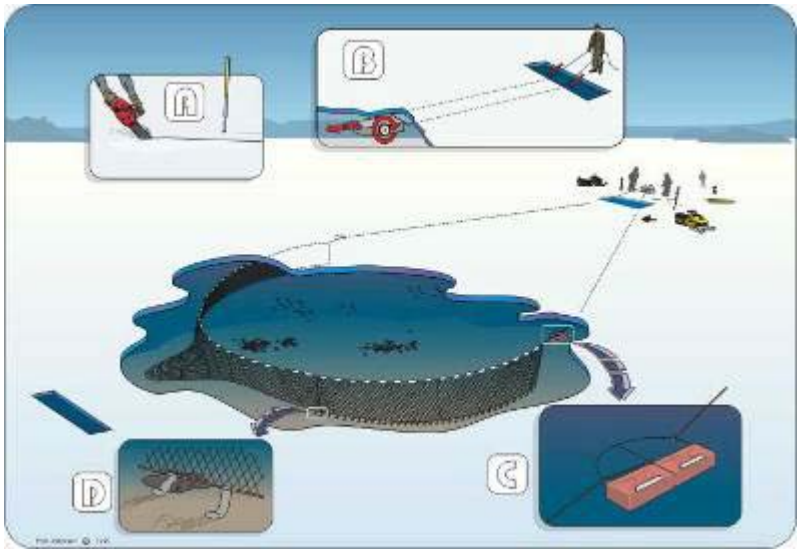

Figure 7. Finnish under-ice seining (Turunen *et al.*, 1997).

14.5 Assessment of Seine Net Fisheries

The group considered the assessment of fishing gears carried out by WGFTFB (ICES, 2006a). This qualitative assessment was carried out with the aim of identifying "responsible fishing methods", with respect to a number of "ideal gear properties". The "ideal gear properties" were considered to be definitive of three key areas of impact, with respect to "Responsible Fishing", and were grouped accordingly to: Controllability of Catch, Environmental Sustainability and Operational Functionality. In most respects, as shown in Figure 8, seining scored favourably compared to other active fishing methods such as trawls.

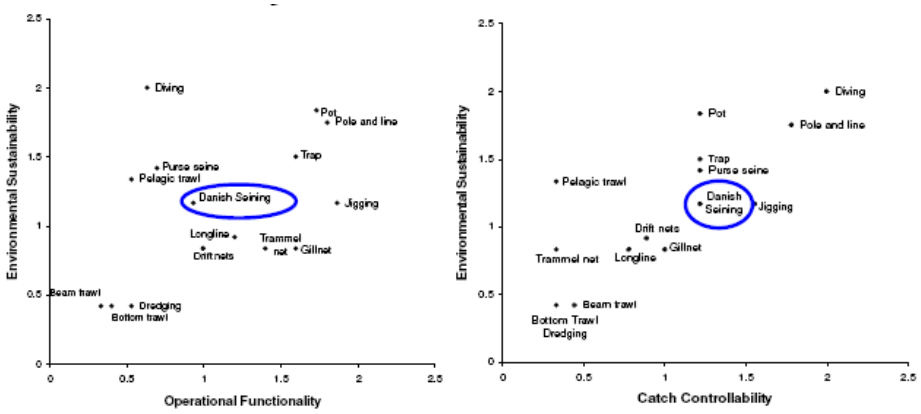

Figure 8. Relationship indices of "Environmental Impact", "Operational Functionality" and "Catch Controllability" for different fish capture methods (ICES, 2006a).

As this analysis shows there are undoubtedly many positive benefits of seining when compared to trawling with respect to bottom impact, fuel economy and fish quality, however, concerns have been expressed that there are negative aspects associated with the method that should be addressed. In some Anchor Seining/Fly-dragging fisheries there are concerns about levels of discarding and high-grading as seine netters aim to maximize returns. Also as the pressure on grounds increase and seiners are forced into areas of harder ground, there is evidence of technological creep in seine net design with much heavier seine ropes and heavy hopper footropes now commonly used. There are similarly concerns in some quarters in the adoption of seine net techniques by French and Dutch vessels given these vessels are often targeting non-quota species such as red mullet for which there is little or no scientific assessment. The Topic Group attempted to look at these aspects and assess whether the positive benefits outweighed the negative ones outlined.

14.5.1 Fuel Efficiency

In most forms seining has been demonstrated to have lower fuel consumptions compared to other mobile fishing gear methods but age and design of the fishing vessel is important and some of the newer vessels built as dual purpose seiners/trawlers may have higher engine horsepower's than is needed for single seine net operations. It should also be pointed out when comparisons of fuel consumption are made accessibility to fishing grounds can be very different depending on the country. Commonly seining is carried out by boats in relatively shallow waters (typically < 200m) on inshore grounds in proximity to their home port. However, there are examples of modern day seine net vessels travelling long distances to fish e.g. French vessels off the south coast of Ireland. As a general rule though, when fishing effectively with seine net gear, catch per unit of fuel is generally low compared to other fishing methods. The Topic group reviewed data from a number of countries and found that seine net vessels generally operated at 0.2 - 0.3 litres of fuel/kg of catch compared to 1–1.5 litres/kg for other active fishing methods.

Icelandic data were reported recently by Guðbergur Rúnarsson of The Federation of Icelandic fish processing plants who showed that the variation in fuel consumption can in fact be large between seine net vessels due to different fishing effort, steaming to fishing ground, age and design of the vessels. In 2008 Rúnarsson collected new data from 9 Icelandic seiners and found the average fuel consumption to be 0.20 l/kg fish with a range from 0.14 l/kg to 0.28 l/kg from these nine vessels as shown in Figure 9 below.

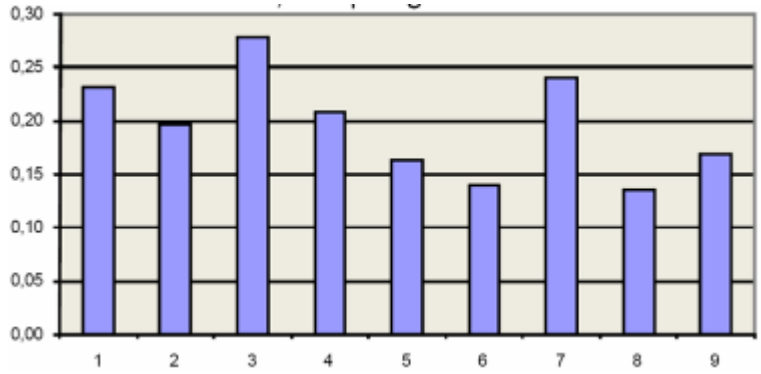

Figure 9. Fuel consumption from nine Icelandic seiners Iceland (Rúnarsson, 2008).

Rúnarsson also compared seine netting to other gears used in Iceland. For bottom-trawlers fuel consumptions was approximately 0.41 litres/kg or twice that of the seiners. Boats using other passive gears, however, were lower with longliners on average using 0.15 litres/kg and Purse Seiners 0.035 litres/kg (See Table 4 below).

Table 4. Oil consumption from some main fishing methods' in Iceland.

Based on data gathered in 1990 to 1997, 2000 and 2008 ((Rúnarsson, 2008)

TYPE OF FISHING BOAT	LITRE OIL / KG CATCH
Pelagic factory trawler	0.09
Purse Seine	0.035
Gillnetters	0.1
Longliners	0.15
Seine netterd	0.2
Bottom trawler	0.42

In Norway, Bouwer Utne (2007) reported similar findings for average fuel consumption for seine nets of ~0.25 l/kg catch (See Table 5 below). This compared very favourably to all categories of trawlers which used much more fuel with the highest being from the shrimp trawlers of 1.8 litres/kg catch (Bouwer Utne, 2007)

Table 5. Fuel consumption by fishing method in Norway (Bouwer Utne, 2007).

TYPE OF FISHING BOAT	KG OIL / KG CATCH
Pelagic factory trawler	0.063
Longliner (costal)	0.205
Seine Net	0.259
Gillnets	0.302
Purse Seine	0.313
Longliner (offshore)	0.380
Bottom trawler	0.8
Shrimp trawler (offshore)	1.8

Thrane (2005) reports data from the Danish seine net fleet compared to the trawling fleet. He reports that the fuel consumption in the flatfish fishery can vary from 2.6 litres/kg for beam trawls to 0.2 litre/ kg flatfish caught with a Danish seine showing the advantages of Danish seining.

Seafish reported economic data for the UK fishing fleet in 2005 and showed that fuel costs as a % of gross earnings were 9.1% for seine net vessels and 12.9% for pair seine vessels (Anderson *et al*., 2008). This compared favourably with the figures for trawlers of between 15–20% and 29% for beam trawlers but was slightly more than the figure for gillnetters of 6%. Table 6 below summarizes these findings.

Table 6. Economic Data for the UK Fleet 2005 (Anderson *et al*., 2008).

SEGEMENT	FUEL AS A % OF EARNINGS
Seine Net	9.1%
Pair Seine/ Pair Trawl	12.9%
Single-rig demersal 12–24m	16.2%
Single-rig demersal >24m	30.8%
Twin-rig demersal	22.8%
Single-rig Nephrops	15.9%
Twin-rig Nephrops	14.6%
Beam Trawl	29.3%
Gillnet	6.3%

All of these datasets show seine netting to be a fuel efficient method compared to other active fishing methods.

14.5.2 Environmental Impact

Seine nets are generally regarded as having low bottom impact, although the group could find few specific studies that had measured the impact of seine net gear. A study by Fuller and Cameron (1998) focusing on fishers' perspectives, most respondents considered the habitat effects of Scottish Fly-dragging and Danish anchor seines to be negligible because areas fished are smooth and already quite flat. WGECO (ICES, 2006b) carried out an assessment of the effects of fishing on the ecosystem in the North Sea and reported that, "*Because of the direct contact of the seine gear coils with the seabed, and fact that the gear relies on the disturbance of the seabed sediment in order to herd fish into the path of the closing seine, this gear in all likelihood has a direct effect on benthic invertebrates within the circle of the gear*". This report details attempts to obtain a first impression of the actual footprint of fishing including seines on the mortalities of benthic invertebrate communities using a benthic impact model. Per fishing event mortality rates for each of the four main fishing gear categories were derived from Tulp *et al*. (2005). The first run used gear average mortalities calculated across 12 benthic invertebrate phyla and these mortalities were found to be 0.25 for beam trawl, 0.1 for two otter trawl fisheries (*Nephrops* and mixed roundfish) and only 0.05 for seine gears, showing seines to have the lowest mortality for towed gears.

Wayte *et al.* (2004) report on an Ecological Risk Assessment for Effects of Fishing carried out for trawl and seine net fisheries in Australia. This is a comprehensive assessment of all of the impacts of the two gear types and identified that trawls had a set of 7 activities that had risk scores greater than 2 (classified as moderate or greater). These activities were: capture by fishing, direct impact from fishing without capture, gear loss, discarding catch, translocation of species, activity/presence on water and disturbance of physical processes by fishing. Other components including target species, by-product/bycatch species, protected or charismatic species, habitats and communities were classified as requiring some additional analysis or manage-

ment response. When compared to the seine gear (fly-dragging), only 2 of these activities had risk scores greater than 2 (moderate or greater). These activities were capture by fishing and discarding of catch. Additional analysis or management response was recommended for the target species and protected species categories. The other components, byproduct/bycatch species, habitats and communities, were not considered at risk from seining, and were eliminated from further consideration in this study.

A recent Canadian study by Donaldson *et al.* (2010) reporting on impacts of Fishing Gears other than Bottom Trawls, Dredges, Gillnets and Longlines on Aquatic Biodiversity and Vulnerable Marine Ecosystems made similar findings. This report concluded that the main impact of seining is bycatch of both undersized individuals of the target species and individuals of non-target species. In addition the authors found that accurate estimates of the environmental impact of these seine nets require more and better quality information on seabed types and habitat but state that the rapid recovery of bivalve molluscs after deep dredging in seabed sediment has been extrapolated to the effects of seine rope contact with the seabed sediment, and is considered minimal (Arkley, 2008).

In October 2008 a small survey was carried out by the Marine Research Institute of Iceland to research if there were any measurably impact on benthos fauna in areas where seine nets where frequently used and to compare this area with a nearby area closed to bottom contacting gears. Underwater observations were made and various methods were used to collect bio-samples from the bottom and in the sediments below. Seine nets were then used in the closed area and similar samples taken again inside that area. No impact could be measured in or outside the closed area or after shooting the seine net in the closed area. This was a small survey with limited data collected and needs to be repeated at a larger scale but supports the view that seine net gear has a low bottom impact.

In terms of other environmental impacts including bycatch of protected species such as marine mammals, pinnipeds and seabirds there are no reported impacts other than a few benign interactions. In Australia, some interactions with seals are noted by Wayte *et al.* (2004) but with no resultant mortality. Donaldson *et al.* (2010) do report catches in the Southern Gulf of St Lawrence by seiners of winter skate (*Leucoraja ocellata)* which has been listed as "endangered" (COSEWIC, 2005; DFO, 2008). With respect to ghost-fishing there is negligible potential because the chances of losing the entire gear are low (FRCC, 1994).

14.5.3 Fish Quality

Fish caught with seine nets are normally regarded as being of high quality, however, the group could find very few specific assessments that have tracked fish caught in a seine from landing on deck to the final consumer. Therefore all evidence to support this assertion is based on indications that fish caught by this gear is of premium quality corroborated by auction prices. Catches from Dutch seiners are generally labelled as E quality at Dutch auctions. As a result, these catches also fetch higher prices per kg (for all species caught). This higher quality may be partly due to seining resulting in better quality, but state-of-the-art catch handling on these modern vessels may also play a role (Van Craeynest pers. Comm.). Despite this, there are yearly claims about poor quality fish delivered by seine netters. When this happens, it is usually felt not attributable to the gear itself but the vessels ability to cope with large catches over a short period (1 to 2 days).

One recent development that does demonstrate the good quality of seine caught fish is the use of seine caught fish for Capture based aquaculture (CBA) in Norway as reported by Midling *et al*. (2008). This has mainly been with wild cod although more recently attempts have been made with haddock which have been largely unsuccessful. This practice has become an interesting alternative to conventional landing of headed and gutted fish. After years of trial and error, and partly under the auspices of governmental authorities, most fishers agreed that seine net is the best gear for both catching and keeping cod alive and in good condition for transport for ongrowing in big net pens. Being fed with herring over a four month period, the cod will manage to double its weight. On average, more than 80% of cod caught during s seine net operation will survive the whole process from catch to transport to the pens. The rest of the fish is not necessary dead, but will not survive due to excess of swimbladder gas in the body cavity.

14.5.4 Selectivity

14.5.4.1 Methodology

With respect to selectivity of seine net gear, the group carried out an initial assessment and identified a number of studies that had attempted to measure seine net selectivity. However, most of these reports indicated that measuring selectivity was problematic given the way seine net gear is operated. Therefore the group initially reviewed the methodologies used in selectivity analysis. These were found to be codend covers (Coull and Robertson, 1985), alternate haul (Anon., 1990; Anon 1991) and trouser codends (Isaksen and Larsen, 1988; Anon., 1991; Anon; 2006). None of these would appear to have given completely satisfactory results. In experiments using covered codends evidence of masking of the codend had been observed. This was clearly shown by Main and Sangster (1988) who made direct observations on a range of seine net codends. They found that if the codend or cover became too full of fish then masking of the codend meshes took place. New cover designs using kites, as described by Madsen *et al*. (2001) instead of hoops may improve this although this technique has not been tested on seine net gear. With regard to the alternate haul and trouser trawl methods, the main problem centres around the extreme haul to haul variation often seen in seine net catches. In addition the trouser trawl can be sensitive to skewed hauling causing asymmetry and an uneven split between the two sides of the net, although Isaksen and Larsen (1988) report on good results obtained using a trouser trawl during Norwegian codend selectivity experiments. Table 7 below summarizes the pros and cons of each of these measurement techniques.

Table 7. Main methods of measuring the selectivity of seine nets.

METHOD	PROS	CONS
Alternate Haul (one of two vessels)	Easy to handle (no covers or collecting bags). No bias in the escape process. Suitable for whole gear selectivity.	Large between haul variability – space and time problem. Control (small mesh) codends potential to catch large quantities of fish causing sampling difficulties – unable to control tow duration unlike trawling. Test/control codends will need to be swapped every haul unless two nets are carried by the vessel, which could introduce between net variability. Due to variability's more hauls will need to be completed compared to twin trawl experiments. Needs double the time due to alternating between test and control codends.
Codend cover and/or collecting bags	Surveys total population entering the net each haul, therefore no need to make two hauls per test case (test then control). Selectivity parameters obtained are more robust as no between haul variability.	Potential handling difficulties with covered codend and/or collection bags. Must ensure no masking occurs so cover must be kept clear of the test codend (e.g. plastic hoops…..). (kites?) Possible flow problems causing fish transfer between test codend and cover. Entangling problem! During the shooting process the net lies slack and not under tension so potential for the cover/codend to become fouled. As alternative haul unable to alter tow duration so potential for very large catches can be encountered and therefore causing masking and handling difficulties. Can not be used for whole gear selectivity.

METHOD	PROS	CONS
Trouser Trawls	Surveys total population entering the net each haul, therefore no need to make two hauls per test case (test then control). Selectivity parameters obtained are more robust as no between haul variability. Easier to handle (no cover). No masking.	Sensitive to skewed hauling causing asymmetry and an uneven split between the two sides of the net. Difficult to design, may influence overall net shape. Unknown effect on herding of fish by the centre dividing panel. Unknown effect on net symmetry of large catches in the control side compared to the test side. As alternative haul unable to alter tow duration so potential for very large catches can be encountered and therefore causing handling difficulties. Possibly no use for whole gear selectivity. Variability!

14.5.4.2 Selectivity Studies

A number of different selectivity devices have been tested to improve seine net selectivity in addition to simple increases in mesh size (Spingle, 2001; Anon., 2002; Anon., 2004; Walsh and Winger, 2010). These include the use of square mesh panels (Arkley, 1990; Ashcroft, 1991; Moth Poulson *et al.*, 1993; Anon., 2002c; Anon., 2006), square mesh codends (Isaksen and Larsen 1988; Walsh and Winger, 2010), grids (ICES, 1998; Larsen and Isaksen 1993), separator panels (ICES, 2002; Inoune 2000) coverless trawls with reduced top sheets ((Tait, 1993; Anon., 1997; Walsh and Winger, 2010) and footrope modifications (Walsh and Winger, 2010; Sheppard *et al.*, 2004). The results from these studies are varied and all of them indicated that while there appeared to be ways of improving selectivity, in practice it is difficult to obtain definitive results as indicated previously. Annex 8 summarizes the most recent studies completed. Summaries of the main results by country are given below. This is restricted in the most part to experiments carried out post 1990.

Canada

Walsh, S. J. and Winger (2010) report on Canadian studies carried out in the period from the late 1980s to the early 2000s looking at the effect of mesh size, mesh geometry and gear modifications to improve size and species selectivity of commercial seine net gear. These studies were carried out in the Southern Gulf of St Lawrence, Sidney Bight and Newfoundland south coast fisheries.

Southern Gulf of St Lawrence

The selectivity of 130mm and 145mm diamond and square mesh codends were compared using the trouser trawl concept in trials carried out between September and October 1993, in the Southern Gulf of St Lawrence. The seine net used was split vertically with a panel running 5 meters forward of the split extension/codend, i.e. 2 extensions with codends. A small mesh control codend with a 55 mm mesh size was used to sample fish populations. Testing occurred over a 53 sea days with 136 successful sets performed with the 4 codend types. The analysis showed that increasing mesh opening in diamond mesh codends to 145 mm would reduce the discards of

flounder significantly; however, it would probably increase the catches of small gadoids. Using 145 mm square would have an almost complete reversal results. A mesh size of 155 mm2 or higher would be required to solve the discard issue of small flatfish and gadoids (Anon, 1994).

A second experiment used two vessels from the Prince Edward Island seine fleet was carried out to look at changing selectivity at the footrope, i.e. grassrope, and involved testing the effect of changing the configuration of the grassrope. The 29 sea day trials were carried out in August and September of 1993 using a variant of the alternate haul method, i.e. each vessel fished simultaneously in proximity and each alternated the grassrope configurations. The results for each vessel were mixed, with vessel 1 showing that the increase in spacing resulted in catching less small flounder and cod and vessel 2 showing the complete opposite. This would imply a vessel effect because the shooting and retrieval methodology was different due to vessel 1 having self hauling rope reels and power block while Vessel 2 had only a winch. The author cautioned this sole interpretation and noted that more studies were needed to investigate a vessel gear effect.

In 1995 a joint project between the Canadian Department of Fisheries and Oceans and the New Brunswick Department of Fisheries and Aquaculture contracted Nordsea Ltd's fishery consultant David Tait to investigate whether a "topless" seine design would release more cod and improve the catches of flounder in Scottish seines. The Scottish seiner, 86.5ft/565 hp M.V. "Mylene H" was chartered and outfitted with an experimental seine which had the top square and belly of the wing trawl removed but in other respects similar to the vessel's wing trawl. Each net was also fitted alternately with identical 155 mm and 175 mm square mesh extensions and codends. The target species were flounder and cod. Seventeen tows were carried out using the alternate haul method Results only for the 1995 tows were tabulated in terms of catch weights with the experimental topless seine catching more flounder than the regular seine trawl when both used 155 mm square mesh codends. Within the experimental seine mesh sizes, the larger 175 mm codends in the experimental seine released more flatfish than the 155 mm codends experimental seine. Based on limited cod data, the topless seine with 155 mm square mesh appear to catch less cod as did the 175 mm square mesh codend when compared to the 155 mm mesh codends in the topless seine comparison (Tait, 1993).

Sidney Bight Fisheries

In September of 1991, the Nova Scotia region of the Canadian Department of Fisheries Industry Services and Native Fisheries Branch working with Danish seining industry funded an experiment to determine the selectivity of 130 mm square and 130 mm diamond mesh codends in Danish seines used to fish various flatfish species, and to compare the results to similar experiments that had been conducted with otter trawls. Two vessels from the Bay St Lawrence area of Cape Breton, Nova Scotia were chartered, with either 130 mm diamond or square codend side by side off the northeast coast of Cape Breton, Nova Scotia. Although there was some problems related to experimental protocols, fish sampling for length composition, and codend twine knots slipping, the results from 11 pair tows showed that 130 square mesh codend retain more flounder and greysole under 37 cm than that caught with 130 diamond mesh codends. These findings are the same seen in otter trawl selectivity experiments comparing flatfish length composition in diamond and square mesh codends (Walsh *et al.*, 1992).

Newfoundland south coast

Two Danish seine vessels (< 65 ft class) from Margaree, on Newfoundland's south-west coast carried out codend selectivity project over a 10 day period during October and November 1996. The objective was to reduce the bycatch weight of cod below 5% and reduced the catch of small flounder below 15% by using larger mesh sizes. Both vessels tested first 145 mm diamond and square mesh codends then secondly the 159 mm diamond and square mesh codends. From the 52 fishing sets with the 4 different codends the cod bycatch ranged from a high of 7.8% in the 159 mm diamond to a low 2.8% in the 159 mm square-cod mesh codend. The results for small flatfish showed that the 145 mm square mesh had the highest percentage of weight of small fish: 4.4% plaice (<30 cm), 6.7% witch (<30 cm) and 12.2% cod (<41cm) and both the 159 mm diamond and square mesh codends had low catches of small flatfish and no small cod. Unfortunately the catches of cod in the test area were small and these results should be treated with caution. However it is clear that square mesh codends retain more small flounder when compared to diamond mesh codends of the same size.

A further industry based codend mesh selection project funded under a joint Canada-Newfoundland Fisheries Diversification Program compared the codend selection of regulation130 mm diamond mesh to 155 mm diamond and square mesh codends to see if the change in mesh size or shape would maximize fish size and catch rates (Spingle, 2001). Four seiners were chartered in September 2000 and each boat alternately used the 3 codends, completing 2 fishing sets for each type for a total of 27 fishing sets. The results showed that there was little difference in average length and catch rates of greysole between the 130 mm diamond mesh codends and 155 mm square mesh codends. However, average size of greysole was larger in 155 mm diamond but the catch rates were lower because of the loss of small-medium size fish along with the juveniles.

Denmark

A number of selectivity studies have been completed in Denmark with anchor seines. Poulsen and Wileman (1991) report on trials carried out on the anchor seine vessel "Doggerbank" in the Kattegat in May 1991. A purpose built trouser net was constructed to obtain measurements of codend selectivity using a small mesh codend on one side in each haul to obtain a population sample. A codend constructed in 100mm x 4mm double PE with 100 meshes in the circumference and with a total length of 10m was compared to a codend with the same mesh size and twine diameter but with 80 meshes in the circumference and only 4.1m in length. The results showed no significant difference in L50 or selection range for plaice although data variability was reported as being a problem in these experiments.

Moth Poulson *et al.* (1993) report on further work completed on the same vessel and in the same area carried out in June 1992. These trials were carried out using a covered codend and tested the effectiveness of 90mm square mesh panels in a variety of positions with a 100mm x double 4mm PE codend. Selectivity data for cod is reported with an L50 of 34.5cm (SR=5.8cm).

Ireland

A catch comparison experiment using the alternate haul method was carried out by BIM in Ireland in 1993 in the Celtic Sea on the seine net vessel "Caronia" (Anon., 1993). The trials tested an 80mm x 4mm standard codend against a standard codend with a 3m x 80mm square mesh panel placed approximately 12m-15m from the cod-

line. No difference between the gears was noted but there was considerable variation between hauls.

Further trials were carried out by BIM over a 20 day period in December 2000 and January 2001 on board the seine net vessel "Fiona Patricia" in the Celtic Sea Prolonged periods of bad weather caused severe disruption throughout (Anon., 2001). These trials were carried out as a catch comparison exercise using paired alternate hauls. A standard 80mm x 4mm codend was tested against an 80mm codend with a 5m x 90mm square mesh panel fitted ~9m above the codline. The panel was reduced to 3m after several hauls and moved a further 3m away from the codline as the skipper felt the panel to be too effective. Only the results with the second panel arrangement were reported, which showed a 10% reduction in whiting catches < mls, a 15% reduction in haddock < mls with a corresponding 15% reduction in whiting catches > mls and 18% haddock > mls.

Two sets of catch comparison trials were completed in 2002 on the seiners "Comet" and "Honeydew" in the Celtic Sea. The alternate haul method was used. The experiments, completed over a 15 day period in February-April on the "Comet", tested a standard 80mm x 6mm single PE codend against a 10mm x 4mm double PE codend in an experimental seine constructed in low diameter/high tenacity twine (Anon., 2002a). The results showed a 13%, 20% and 16% reduction in whiting, haddock and hake catches < mls. Marketable catches of whiting were reduced by 45% although no reductions for other species were found. The trials on the vessel "Honeydew" were carried out over a 13 day period in March-May and tested an 80mm x single 4mm PE codend against a 100mm x 4mm double PE codend (Anon., 2002b). Bad weather hampered the trials as well as problems with the codends tested. The results from these trials showed reductions in whiting, haddock and hake catches < mls of 14%, 4% and 25% respectively with a 30% reduction in haddock > mls, mainly fish just above the mls. Variability between hauls was recorded as a problem in both trials.

In August 2004 a further set of trials were completed in the seine net fishery off the South coast of Ireland on board the "Cisemair" using the alternate haul method and a 40mm small mesh retainer bag (Anon., 2004). Selectivity data for haddock was gathered on a standard seine net with a 90mm codend x 6mm single PE codend; with a 100mm codend x 6mm single PE codend and a 110mm codend x 6mm codend. The L50s obtained were 30.14cm (SR=8.31cm) with the 90mm; 34.47cm (SR=7.34cm with the 100mm; and 36.87cm (11.36cm) with 110mm. Considerable variation between hauls was noted during the experiments.

A short trial was conducted in September 2005 on the seine net vessel "Harmony". The trial had the objective of testing a 90mm x 6mm single PE codend against a 110mm x T90 codend. Major problems were encountered during the trials due to difficulties with the T90 codend and the experiments were aborted.

Further trials were carried out in November-December 2005 on board the seiner "Roise Catriona" in the Celtic Sea (Anon., 2006). These trials used a trouser trawl, with the trawl divide by a sheet of netting running from the mouth of the seine. These experiments were carried out as a catch comparison testing a standard 100mm x 6mm single PE codend against a 90mm x 6mm codend; a 90mm x 6mm codend with a 90mm square mesh panel; and a 100mm x 5mm single PE with a 90mm square mesh panel. The results were largely inconclusive due to the large haul by haul variation in catch rates but did suggest a reduction in haddock and whiting discards when a square mesh panel was used.

Norway

The first selectivity experiments performed in Norway were carried out in 1982–1983. This work concentrated solely on increased mesh size from 110mm to 135 mm (Jakobsen, 1982; 1985). Following introduction of new regulations following this work, however, to counteract the effect of the large increase in mesh size, the fishers began to use heavier twines in their codends.

Following on from this during June 1986 further work was carried out with diamond mesh and square mesh codends on board the seine net vessel "Karl-Viktor" off the Finnmark coast (Isaksen and Larsen, 1986). Comparisons between different codends were made initially using the alternate haul method but after several unsatisfactory attempts this was a trouser trawl fitted with a small mesh codend. The trouser trawl was constructed with an 8m long vertical panel in the mouth of the seine which divided the extension and rear belly of the trawl into two equal parts. Diamond and square mesh codends of 120mm and a diamond mesh codend of 135mm were tested. The square mesh codends gave improved selectivity for both cod and haddock. The selection factor for cod was measured at 4.7cm in the square mesh codend compared to 4.5mm in the diamond mesh codend. The selection range was 8.5cm in the square mesh codend, compared to 13.5cm in the diamond mesh codend. A few hauls comparing the 120mm square mesh codend and a 135mm diamond mesh codend were carried out. These hauls showed a high loss of marketable cod (> 42cm) and hardly any haddock less than 50cm in the bigger mesh codend. The trouser trawl method was reported to be advantageous compared to the alternate haul method as there appeared to less variation in catches between hauls.

On the basis of the good results from grid experiments in demersal and shrimp trawls a few experiments were carried out with seine net with grids in 1991. The grid device, however, turned out to be very difficult to handle on board a seine net vessel, especially during retrieving the net belly and codend system. After some parallel testing of grids and square mesh codends, it was found out that a 125mm square mesh codend gave the same release of small gadoids as a rigid grid with a bar spacing of 55mm and comparable to a 55mm grid used in whitefish trawls (Larsen and Isaksen, 1993).

This lead to a working group being set up in 1995 which recommended further testing of square mesh codends in seine net trawls. Following this work legislation requiring the use of a square mesh codend for seine net was introduced in 1997. Since its introduction, the handling of large catches more than ten tonnes, has given some practical problems, mostly due to the allowable twine diameter of the square mesh codend. To counteract this fishers have more recently begun to use square mesh codends with wedge-shaped side panels of diamond meshes, which have improved handling properties. Subsequent Experiments performed by the Directorate of Fisheries and Institute of Marine Research have shown no difference in selectivity in square mesh codends with and without wedge-shaped side panels.

ICES (2002) reports on Norwegian trials with separating panels used in seine net gear. The panel consisted of a small-meshed guiding panel in front of a square mesh horizontal separating panel. Experiments with a 200 mm panel improved the separation between cod and haddock compared to 300 mm mesh size, indicating the species separation is a combined function of behaviour differences and size selection.

UK

During the 1980s the Marine Laboratory in Aberdeen carried out a number of experiments investigating the codend selectivity of seine nets and also the use of square mesh codends. This is reported by Robertson (1984) and Coull and Robertson (1986).

More recently Seafish and the Marine Laboratory in the UK carried out trials on the Scottish seine net vessel "Kestrel" (INS 253) in February-March 1990 in the North Sea testing 75mm square mesh panels with 90mm diamond mesh codends (Arkley, 1990a). Both clean seines and rock-hopper seines were tested. The alternate haul method was used and the trials were conducted as a catch comparison exercise. Fishing was generally poor during the trials but a reduction in haddock (44.6% with the standard seine and 38.7% with the smp) and whiting discards (8% with the standard seine and 2% with the smp) was found with the 75mm square mesh panel.

Further experiments were carried out on the same vessel later in April 1990. These trials tested a standard 90mm x 120 meshes round codend against a 90mm x 100 meshes round codend and a 110mm codend x 100 meshes round (Arkley, 1990b). The trials were carried out using a hooped codend cover, which proved difficult to handle and also was found to mask the codend significantly. Selectivity data for haddock and whiting were obtained for the three codends, however were obtained. With the standard 90mm x 120 mesh codend L50 for haddock was 23cm (SR=6.1cm) and 29.2cm (SR=9cm) for whiting. For the 90mm x 100 mesh and the 110mm x 100 mesh codends L50s of 25.4cm (SR=4.7cm) and 26.2cm (SR=5.9cm) for haddock and 26.2cm (8.2cm) and 32cm (SR=19.6cm for whiting were found respectively. Overall the 110mm codend reduced haddock catches by 60% but a reduction in 54% of marketable haddock.

Trials carried out on board the Scottish seine net vessel "Kilronan" (INS10) in September 1991 tested 90mm square mesh panels in standard seine net gear using the alternate haul method are reported by Ashcroft (1991). Initially two 3.3m long 90mm square mesh panels were inserted in the upper part of the straight extension, the first one situated 8m above the codend lifting becket and the second one 14.5m above the lifting becket, The catches were compared to a standard 90mm diamond mesh codend. Later in the trials the panels were moved closer to the codend. The discards of undersized whiting were reduced but there was also a loss of marketable fish. The same result was found for haddock and the reduced discards and marketable fish were comparable to those for whiting. Considerable haul by haul variation was noted.

The Lerwick registered seiner/trawler "Harmony" (LK63) measuring 23.18m overall was chartered for 15 days during April 2001 to carry selectivity trials (Anon., 2002c). Fishing was carried out in 'Scalloway Deeps'; commercial grounds approximately 15 miles SW of Scalloway in the Shetland Islands. A total of 40 hauls were made during the trials. The main aim of the project was to measure the effect of adding a 90mm square mesh panel on the selectivity of a 100mm-diamond mesh codend in a seine net. Three different panel positions were tested to assess the effect for a seine net vessel in the smaller horsepower range (440hp). The paired alternate haul method was used to compare the catches between the two test extension/codend configurations. Adding a square mesh panel at the 9–12m position reduced haddock discards by 56% and smaller grade marketable haddock by 48%., while adding the panel at the 3–6m position however, had a much smaller effect, reducing discards by only 19% and having no significant effect on catches of marketable haddock. Comparing the two panel positions shows that the 9–12m position was more selective, releasing

more juveniles and small marketable fish. For whiting, no significant differences in discards or catches were detected except for a large drop in sampler grade marketable whiting when the panel was added at the 9–12m position.

The pair seine team "Jasper" (PD174) and "Crystal River" (FR178), were chartered for 15 days during May 2001 to carry out catch comparison trials on commercial fishing grounds NE of Lerwick in the Shetland Islands (Anon., 2002c). The main aim of the project was to investigate the effects of proposal changes in technical measures legislation on landings and discards. The experiment measured the combined effect of changing extension length and square mesh panel position and removing the lifting bag on the catch of vessels in the pair seine fleet. A total of 40 hauls were carried out during the trials. The paired alternate haul method was used to compare the catches between the two test extension/codend configurations. During these trials no statistically significant differences in total catches or individual catches of haddock, whiting or cod were found when the lifting bag was taken off, the panel moved aft and the extension length reduced. Other trials, on single and twin demersal trawls, to look at these issues separately found that there were effects for lifting bag and panel position but not extension length. Four different grounds were fished and significant differences in catch rates between grounds were detected. These are likely to be due to availability of fish. Identification of an effect between grounds shows that the catch comparison technique was sensitive enough to detect significant differences.

Further trials were carried out over a 14-day period during July 2001 by the Lerwick registered seine net fishing vessel "Harmony" (LK63; 23m, 298kW; Anon., 2002c). The trials were carried out on fishing grounds to the west of Shetland, primarily in the Burra Haaf and St Magnus Bay areas. A total of 94 shots were made. The aim of these trials was to assess the effect on the catches and discards of a Scottish seiner of increasing codend mesh sizes from 100 to 110 or 120mm. The 110mm and 120mm codends were compared to the normal 100mm codend by carrying out a series of pairs of alternate shots, one with the 100mm codend and the other with the codend being tested. The catches taken in each pair were then compared. 110mm codends with and without a 90mm panel and 120mm codend significantly reduced catches of undersized haddock and whiting compared to a 100mm codend. The 110mm codend without a 90mm panel significantly reduced catches of marketable haddock up to grade IV and of marketable whiting up to grade III. The 110mm codend with a 90mm panel and the 120mm codend also significantly reduced catches of marketable grade II whiting and also for grade III haddock, but only for the 120mm codend. Fitting a 90mm square-mesh panel in the 110mm codend substantially reduced catches of both undersized and marketable fish.

Other Countries

Thorsteinsson (1979) reported on a selectivity analysis carried out off Iceland in 1979. No details other than that a 166mm codend was tested and no results are reported.

Gray *et al.* (2000) report on experiments with strategically placed panels of transparent mesh in an estuarine seine net in Australia. The panels were placed in the anterior region of the bunt and made from transparent netting (mono and multifilament). Covers over the bunt and codend allowed the numbers of fish escaping to be quantified. The panels resulted in an improvement in size selection of targeted commercial species (mainly sand whiting *Sillago ciliata*) and a reduction the bycatch of other species. The authors did acknowledge that the cover was seen to modify the escape responses in some cases, with some smaller fish re-entering the main net.

Okei (1998) reports on trials carried out on Danish seine gear in Ishikawa, Japan with different codend mesh sizes to improve the selectivity for sea bream. The experiments were carried out using an alternate haul method and the standard 31mm codend used in the fishery was compared with 56mm and 72mm mesh size codends. The 56mm codend was found to be the most effective with a 50% reduction in discards of bream although there was a corresponding loss of marketable bream of 30%.

Experiments with a separator panel inserted in a Danish seine are reported by Inoune (2000). These trials were carried out off the northwest coast of Hagi, Japan in November 1996 and May 1997. The actual arrangement and how the panel was rigged is unclear but the results suggest that the panel was at least partially effective at sorting species.

Sheppard *et al*. (2004) report on one observation trip carried out in the southern Gulf of Maine and in Cape Cod Bay groundfish fisheries with a seine net rigged with a raised footrope. This followed on from early work with trawls construction with a similar raised footrope arrangement to reduce bycatch of primarily cod in a directed small mesh whiting fishery. The objective of this short trial was to assess whether this modification could be adapted to seine nets. Only 3 hauls were completed and the results are inconclusive although showed that it was technically possible to adapt this design to seine net gear.

14.5.4.3 Survival

Several experiments have looked at the survival of fish escaping from seine nets. Hislop and Hemmings (1971) observed that haddock brought to the surface by Danish seines and trawls from depths of between 25 and 50 m then returned to the seabed by divers suffered minimal obvious physical impairment, although some individuals may have ruptured their swimbladders. In these experiments there did not appear to be any difference between the survival rates of fish caught by the seine net gear and the trawl gear. Dunning *et al*. (1989) noted mortality of 16% and 17% for fish released from trawls and seines respectively but reduced this figure to around 1% with improved handling practices. However, Fritz and Johnson (1987) estimated a mortality of 84.7% of fish released from a seine as a result of forced swimming, struggling and injury although this was for freshwater species. Later experiments by Soldal and Isaksen (1993) showed survival rates of up to 95% for haddock escaping from Danish seines with 135mm diamond mesh codends.

14.5.5 Discarding

The group found evidence of high discarding in a number of seine net fisheries. Alverson *et al.* (1994) identified the North Atlantic seine net fisheries for cod, haddock and whiting as being among the top twenty fisheries giving the highest discard ratios by number of fish (i.e. discard number per landed target species catch number). For cod the ratio was 0.79, for haddock 0.70 and for whiting 0.64. STECF (2006) reported discarding in seine net fisheries in the North Sea of approximately 20% for all species. Discarding/high grading by seiners in the North Sea is put down to low prices for round haddock and also due to quota restrictions but can vary from zero to around 30% depending on area (Mair pers.comm.). STECF (2008) also report discarding of haddock to be high in the Irish seine net fishery in the Celtic Sea, with observed discarding of haddock at over 50% by total catch weight and of 10%, 16% and 32% for whiting, cod and hake respectively. STECF concluded that as for the North Sea, haddock and whiting discarding was due largely to poor selective properties of the gear and lack of a market for fish at or just above MLS.

Pálsson (2003) identified significant discarding of haddock in Seine net fisheries in Iceland. In an report (Pálsson *et.al.*, 2009) for monitoring changing in discard rates of cod and haddock for most common fishing gears used in Iceland in Seine net fisheries, in terms of weight of cod the discard was low in the period from 2003 to 2008 but at the year 2001 and 2002 the discard rate was over 7% and higher than other gears in this monitoring. Haddock was discarded over the period 2001–2008 highest (~12%) and lowest (0%) rates of measured discard rates of any fisheries in Iceland. Other species have not been measured for Seine net fishery in Iceland but surely some non-quota species are discarded by up to 100%.

In Norway, even with a discard ban in place, Valdermarsen and Nakken (2002) estimated discarding in the Norwegian Danish seine net fisheries to be in the order of 5–9%, mainly due to illegal high grading. This was quite high compared to similar estimates made for trawling (1–5%) and purse-seines (3–9%). In Australian Danish seine fisheries, as reported by Wayte *et al*. (2004), have very low discard rates for quota species in this case flathead and whiting, but high discards rates up to 100% for some non-quota species.

14.6 Use of flume tanks for seine nets observations

Flume tanks are built for towed fishing gear, but in terms of seine nets they have the limitation that it is not possible to simulate the initial steps of closing in of the ropes. The procedure of testing seines in a flume tank is therefore that the ropes are laid out along the walls of the tank and the net is spread out across the tank by force. In this stage there is no flow on the water and the shape and height of the net can be observed. Then the water flow is started and the net soon reduce height and stretches out. When an equilibrium is reached the net is probably in the stage where it – in reality – is starting to let the fish in which are herded by the ropes and is about to take up a position in front of the bosom. From there on the rest of the fishing operation can be studied fully by a careful setting of the distance between the towing masts in the tank and the hauling speed. It is during these later stages that it is possible to optimize the performance of the seine in terms of height, spread, bottom contact etc. etc.

14.7 Technology Creep

Thomson (1981) in his book on seine fishing commented on the rapid technology development in seine netting in the period from 1968 to 1980. Since then there is continuing evidence of technological creep in seine net fisheries. The group carried out an initial review of technological changes in seine net fisheries and summarized the major changes as follows:

- Net Design
- Seine Rope
- Deck Machinery
- Gear Monitoring Equipment
- Move to Pair Seining and Tow-Dragging
- Dual Purpose vessels

14.7.1 Net Design

Seine nets used in Scotland, Ireland and Denmark as well as by vessels from the Netherlands and France, Iceland, Japan and Australia are conventional wing trawls,

i.e. nets made from an upper and lower panel with lateral selvedges (lastridges) and a small square.

The types of groundgear are as varied as in trawls (as shown in Figure 10):

- Clean ground seine nets which are typically larger than trawl nets although lighter in construction having rope footropes (grass ropes). Other vessels tend to use small rubber disc footropes.
- A special variation in groundrope design is used in Norway called a "skirt", which developed from the traditional grassrope. This device was originally designed for purse-seine for saithe (Isaksen pers. Comm.). The skirt net is placed under the fishing line from wingtip to wingtip, and has a height from 50 cm to 150 cm very much dependant on the type of bottom the gear is used. A thick grassrope is attached to the lower part of the skirt. A heavy chain mended onto the grassrope gives both the groundrope and the gear as a whole a negative buoyancy of 100 to 150 kg. The skirt itself is mostly made of polyethylene netting with a mesh size of 140 to 160 mm, and a twine diameter of up to 8mm. The netting is cut on bars, and the skirt with the grassrope is mounted on the fishing line with a square mesh configuration. The skirt net is equipped with adjusting chains on both front ends. When fishing on smooth bottom, the chains are shortened and the bottom groundrope will be pulled in front of the fishing line. In this position, the gear gives very good bottom contact with a rigging very suitable for bottom dwelling species like flatfish, catfish and monkfish. When fishing on rough bottom, the adjusting chains are lengthened, and the grassrope will follow behind the fishing line. Due to the skirt leaning backwards rigged in this manner, the gear will slide very easy over stones and other debris on rough grounds.
- Rockhopper Seine Nets have been increasingly used by fly-draggers over the last decade to enable seine gear to be towed over harder ground. Rubber discs tend to be of 6", 8", 10" and 12" discs. These nets are similar in circumference to demersal trawls but usually lighter in construction and longer in the wings. French and Dutch seine nets tend to have the discs very tightly packed on the footropes at the centre of the footrope.

Figure 10. Examples of Grassrope and Rockhopper Footropes from seine nets.

Other than the Icelandic study reported in section 10.5.1.2, no other specific studies looking at the impact of seine net groundgear on the seabed were found.

14.7.2 Seine Rope

There is a difference between Anchor seining and Flydragging in the length of the ropes deployed. Anchor seiners are normally using 15 – 20 coils per side while fly-draggers are using less often 10 – 15 coils. Ropes are mostly made from3 strand poly-propylene of a very hard laid and lead cored to ensure quick sinking and good bottom contact. The diameter can be anything from 18mm-55mm on the largest vessels with weights of 74kg/220m up to 200kg/220m. Increasingly there has been a move towards heavier rope. The motivation for this is not altogether clear but the indications are that it is twofold: to maintain bottom contact even at increased hauling speed and to improved the lifespan. Pair seine vessels in recent years have begun to use combi-seine rope in combination with seine rope. Combi-seine rope is usually 4-strand or 6 stranded with steel wire strands through PP rope. It is heavier than seine rope with 40mm diameter combi-seine rope weighing 372kg/220m. Again similar motivations with regard maintaining bottom contact and lifespan are indicated.

The Group considered whether the move to heavier seine ropes and combi-seine rope has increased the potential bottom impact of seine net gears. However, there was no evidence to suggest this was the case but this was an issue that the Group felt should be explored.

14.7.3 Deck Machinery

Traditionally the hauling and shooting of the seine net could be a time consuming, labour intensive and dangerous business. It started by coiling the ropes on the deck by hand then flipping them over manually, ready for shooting again. As reported by Thomson (1981) the Beckles coiler which coiled the rope after it came off the winch revolutionized this process followed by the introduction of net bins which were basically large storage bins embedded into the deck, the top of which were at deck level. The ropes came off the coiler and fell into this storage area so the crewman had now only to jump down periodically to stamp down the ropes ensuring they would all fit in. From this came rope reels, which basically turned in conjunction with the winch when hauling. When shooting, the ropes were taken off the winch and free-spooled straight off the reel with a slight braking pressure to stop the reel from overrunning. All these ideas basically meant less manual intervention in the hauling and shooting process thus making it safer and less labour intensive.

In a number of countries the most recent development has been the introduction of power reels, which have rendered the seine net winch and standard rope reels obsolete as they do the job of both i.e. raw hydraulic power to pull the gear back in and tangle free storage capacity for the ropes. A conservative estimate of time saved on a complete cycle of the seine net would be roughly 20% from the use of power reels. In the short daylight hours of winter this amounts to an extra haul per day (Mair pers comm.). Power Seine rope reels are also equipped with tension sensors and rope counters. Some systems have software that processes data from both reels and controls the hydraulic pumps powering the starboard and port reels, allowing the skipper to reel in both seine ropes equally (equal length or equal tension) regardless of bottom resistance or small obstacles. Together with high fuel prices, the system has played an important role in the recent uptake of seine fisheries in the Dutch fishing fleet as it greatly reduces gear damage and the level of experience required to attain commercial catch levels (Van Craeynest pers comm).

The Group considered the development of power reels as a step forward in terms of safety but undoubtedly will improve efficiency in terms of extra fishing time for vessels.

14.8 Gear Monitoring Equipment

There has been considerable development in gear monitoring equipment available for the monitoring of seine nets. This has always been a problem with this type of fishing given the gear is susceptible to tide and weather. Traditionally the only equipment available to seine netters has been simple rope counters and tension meters. In recent years a number of new monitoring systems have become available and Table 8 below summarizes the range of sensors now available.

Table 8. Summary of gear monitoring sensors now available (produced by Thor Bærhaugen of Simrad).

Sensor type	Function	Comment
Depth sensor	Measures the depth and descending speed of the gear. (measures water pressure)	Start fishing when the seine net is on the bottom. Sink rate varies with tide, rope, web etc.
Spread sensor	Measures the horizontal distance between wing ends. (one sensor on each wing)	Know when wings are closing. Get the most out of each setting.
Geometry sensor	Detects uneven ropes lengths. (Measure length from centre of headrope to both wings. Main sensor mounted on headrope, transponders mounted on wings)	Detects if you need to regulate rope length on one port or starboard side. The seine net is fishing at its best when the geometry is correct.
Height sensor	Measure vertical opening of net. (based on echosounder principle)	Can be mounted on groundrope to detect bottom contact.
Seine Sounder	Depth and Height sensor combined	Depth and Height sensor combined

14.9 Pair seining and Tow-Dragging

Since the early 1990s there has been a steady switch in Scotland from single seining to pair seining with only 20 single seiners operating in Scotland from January 2010. Pair seining is recognized as being more efficient and simpler than traditional single boat seining and this seems to be the main motivation in Scotland for the steady transfer of effort. Pair teams will in general work longer trips 6–11 days, going farther afield to work. Modern pair seining is very difficult to distinguish from pair trawling as the ropes use a combination of seine rope or combination and warp. The gear is also towed for much longer for up to 5–6 hours compared to around 1–2 hours for a single seine and the operation should now be considered much more akin to trawling than seining in this regard.

In several countries e.g. Norway and Japan there is also evidence of seiners fishing in depths in excess of 250m by modifying their operation to combine seining with trawling, sometimes referred to as tow-dragging (Thomson, 1981). The gear is set from a free-floating buoy then towed forwards in a way similar to fly-dragging except that the winch is not used until the two warps have come together and the net is closed.

The Group recognized that the increased move from seining to pair seining represents an increase in effort compared with single seining. It also felt that pair seining is very similar to pair trawling and therefore may have an increased bottom impact

compared with traditionally seining. Similarly the move to tow-dragging also represents a potential increase in efficiency.

14.10 Dual Purpose Vessels

Most Dutch seiners (9 out of 10) have been equipped with both trawl winches and seine reels, allowing them to switch between both fishing methods in response to lower catch rates or quota issues. Initially, it was planned to combine seining for non-quota species in the English Channel during winter with trawling for plaice in the North Sea during summer (these fisheries were already in practice with dual purpose eurobeamers/twinriggers). It was believed that only North Sea summer cod fishery could be economically viable for seiners but such a fishery would be prohibited by quota issues. However, seine catch rates for non-quota species in the North Sea have exceeded expectations prompting most vessels to go seining year-round. In this way, plaice quota can be rented out or switched to another vessel (beamer) within the company.

Similarly in Ireland, Denmark, Iceland and Norway vessels have been increasingly built or modified to allow easy switching between trawling and seining. At least three Irish vessels built in the last 5 years have all been built with rope reels and trawl winches installed. This has largely been motivated by the need to shift fisheries quickly if catch rates are low with either gear type or to shift from groundfish to roundfish fisheries.

14.11 Conclusions

An assessment of seine netting has been undertaken by the Topic Group and identified some positive and negative effects of this fishing method. From the assessment the group carried out it concluded that seine netting appears in many respects to still be an environmentally friendly fishing method. All of the information reviewed showed seining to be fuel efficient, with high catch quality and low environmental impact when compared to trawling. The group, however, noted concerns regarding discarding levels in some seine net fisheries e.g. North Sea and Celtic Sea, as well as In Iceland, Norway (even with a discard ban) and in Australia for non-quota species.

With respect to selectivity the Group reviewed the methods used to measure the selectivity of seine nets. These methods were alternate hauls, covered codend and trouser seines. All of these measures have their problems mainly relating to variability between hauls. This seems to be a particular problem with seine net gear.

The group also reviewed the most recent selectivity experiments carried out globally. A number of different selectivity devices have been tested to improve seine net selectivity in addition to simple increases in mesh size. These include the use of square mesh panels, square mesh codends, separator panels, coverless trawls with reduced top sheets and footrope modifications. The results from these studies are varied and all of them indicated that while there appeared to be ways of improving selectivity, in practice it is difficult to obtain definitive results as indicated previously. Despite this the results of some of these experiments have been used as the basis for legislation, notably in Norway and Canada. Although the process of fish capture in a seine is quite different from a trawl, selectivity experiments do not indicate higher selectivity or lower discard rates for seines compared to trawls of the same codend mesh size. With respect to square mesh codends research in Canada, Norway and the UK has shown they retain more small flatfish but less small gadoids when compared to diamond mesh of the same size. Thus they seem applicable in gadoid fisheries provided

appropriate materials can be found. Square mesh panels seem to improve the selectivity of seines although the optimum position for the panel still needs to be resolved. Other devices such as sorting grids and separating panels have been shown to be reasonably effective but the research in Norway suggests that at least with respect to grids that changes to mesh size and shape are more applicable to seine nets. The more novel gear modifications tested such as the "topless" seine and modifications to the footrope look encouraging but there is not enough data to make any firm conclusions. The limited Scottish data available for pair seines suggests that there are differences in selectivity of this gear compared to demersal trawls and single boat seines but this is poorly understood.

A few experiments investigating the survival of fish escaping from seine nets were reviewed. High survival rates had been observed for gadoids and in Norway this has resulted in seine net fish being used for capture based aquaculture. On average, more than 80% of cod caught during seine net operations have been found to survive the whole process from catch to transport to the pens.

The group also noted some elements of technological creep to be potentially negative, in particular the move in the North Sea towards pair seining as opposed to single boat seining and also to tow-dragging in deeper waters in a number of countries. These adaptations to seining are considered to be more akin to traditional trawling and potentially may increase the benthic impact in these fisheries. The group felt therefore that there is a need to carefully consider whether these gears are actually "seines" in the true sense when framing legislation which differentiates between seines and trawl gear. The group also considered the use of heavier seine rope and heavier groundgears in some seine net fisheries but could not make any firm conclusions whether these significantly increased impact. The development of better deck machinery and gear monitoring equipment was felt by the group potentially to increase fishing efficiency but also to improve safety on-board seine vessels and so has positive and potentially negative effects.

14.12 Recommendations

On the basis of the work by the Topic Group, WGFTFB recommend the following:

i) Given the resurgence of seining as a fishing method in some countries and the technology creep noted, WGFTFB recommends further assessment to substantiate the environmental friendliness of seining. Environmental impact studies should specifically look at discarding, different seine rope construction, rock-hopper groundgears, hybrid seining operations (pair seine, tow-dragging), changes in operation e.g. hauling speed/power reels and fuel consumption.

ii) WGFTFB recommends an ICES workshop be held to review the results of selectivity experiments with seine net gear and assess methodology for measuring the selectivity of seine nets, which has proven problematic in the past.

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15 ToR c): Gear Monitoring Systems

15.1 General overview

An overview of the topic was given by Antonello Sala to plenary at the start of the 2010 meeting.

15.2 Terms of Reference

Gear mensuration sensors are widely used by researchers to improve selectivity, reduce fuel consumption, and to reduce bottom impact. These systems contain multiple components that collect large quantities of data. To improve the use of these systems, the topic group was formed to:

1) Compile an inventory of current gear monitoring systems including remote data collection devices that can be mounted on gear (pitch and roll sensors)

2) Assess these systems based on experiences and identify problems associated with each system both for gear research and survey. This will be carried out in discussion with manufacturers.

3) Gather and review data collection software both manufacturers and purpose built software.

4) Recommend improvements to existing systems as well as additional gear parameters that would be useful to measure.

The group decided to focus on trawl gear monitoring systems and to assemble and develop suggestions for further improvement in discussion with manufacturing representatives, who were invited to join these discussions.

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15.4 Overview

The Group met during 2–3 June 2010 in Copenhagen, Denmark, convened by Antonello Sala. Michael Pol was rapporteur. A total of 13 scientists and equipment manufacturers participated in this Topic Group. Seven presentations were made to the group.

15.4.1 Description of developments in sensor capabilities

Shale Rosen (SCANTROL/IMR) the CatchMeter: video monitoring and real-time species and length analysis of fish in a trawl

A video system capable of photographing and automatically measuring and speciating fish was presented. The system collects individual photographs and video of fish passing through a restrictive space in the codend and passes the information through the sonar cable to the bridge of the fishing vessel. An estimate of the current system cost was in the tens of thousands of Euros. See also Section 18.1.9 for further information.

Agustín Mayans (Simrad Spain): Simrad fishing gear monitoring systems with data logger integrating all relevant data on fishing operation. Fleet management and fishing effort control concept

Simrad Spain has developed a system to control the bottom fishing gear of the Spanish Mediterranean fleet, operating close to the new gas pipeline laid by Enagás in 2009. The system monitors and records all the fishing gear parameters with the geographical position of each sensor (installed on the doors and the headrope centre) relative to the pipeline. The company created a fleet management control system called SDR-10 which can offer a great benefit for ship owners, researchers and fishing control authorities. Simrad achieved a 41% fuel saving trawling, using the SDR-10 together with new Thyboron T-15VF doors and a new trawl net design. Furthermore, Simrad produces three other types of commercial trawl monitoring systems, two wireless and one with a wire connection between the vessel and the towed equipment.

Further information on the efficiency project is available from the website on the Vigo Symposium; the Enagas project has a website being launched. Cost of the data logging system for fishing vessels was reported to be approximately €15,000. It was pointed out that the pelagic door rigging still required hanging a chain clump between the door and net, in contact with the seabed. The fleet management system is not connected to any electronic logbook system.

Knut Halvorsen (SCANMAR, Norway): New SCANMAR developments (i.e. Temperature compensation)

The ScanBas and ScanMate systems are available in ranges from a two sensor system up to the ScanBas /ScanScreen with the possibility to use 25 sensor functions and two Trawleyes. ScanCheck, a portable system is available in a suitcase as a complete system. The communication link, ScanLink, secures reception under more or less every condition with the possibility of automatic selection of up to four hydrophones. Receiving control is available directly on the screen in operator mode. Automatic compensation for variations in temperature which have impact on distance, height and echosounder measurements is a new function in ScanBas. The new multifunctional sensor generation for trawl and doors is configurable with single or multiple functions. The sensors are flexible and programmable from new chargers regarding frequency, source level, and update rate. Functions may be switched on and off. The sensors are provided with high capacity lithium ion batteries with 10 times higher capacity and significant extended operation time. ScanCharger, a new charger/ sensor programming and maintenance unit will charge the high capacity batteries within 1

to 2.5 hrs. The new DoorAngle sensor can also be used as a Bottom Contact sensor. Correct installation of the door angle sensor is essential. A calibration instrument is available from SCANMAR that will accurately measure the offset of the sensor housing in the original installation.

Speed of trawl through the water and compensation for crosscurrents is the absolute key factor for successful gear performance during surveys. Introduction of roll and pitch measurements in trawl sensors will provide detailed information about the performance of the trawl and codend by indicating pitch, roll and twisting of the netting. Successful catching may also be monitored by changes in pitch values as fish move backwards in the gear. The trawleye sensor is now the most commonly used headline sensor due to its high update rate and resolution. In pelagic fisheries it is also frequently mounted in the belly area of the net to monitor fish movement to the codend.

The group suggested that special courses on mensuration systems would be useful. Another questioner requested improved announcements of software upgrades. The update rate on the bottom contact sensor was clarified as being selectable for 5 different speeds, with 2.5 seconds being the fastest. It was confirmed that an echosounder output can be input into the system. SCANMAR systems are not normally available for rent, but SCANMAR are willing to cooperate with research institutes by loaning equipment for specific projects.

15.5 Experience and challenges using net mensuration systems

Mike Pol (DMF, USA). Summary of Net Mensuration Meeting on 23 March 2010

A meeting was held in New Bedford, USA to address concerns about net mensuration gears and analyses and assemble suggestions to further discuss with the larger topic group and provide them to sensor manufacturers. The following topics were discussed: software, output data, gear handling logistics, reliability of gear and software, gear maintenance, and service. Within each of these sections, the most important weaknesses were identified as well as lesser weaknesses.

The following major weaknesses were identified by the group and do not apply equally to all products from various manufacturers: weak or uncertain outputs; unpredictability/unreliability of systems; time stamp coordination; non-customization of logging/output files; working paravanes: sensor calibration; battery level indicator; maintenance/shipping; physical modifications. Additional concerns and positive trends were also described.

It was pointed out by the audience that simple sensor "first aid" should be able to be done locally, and that batteries necessarily require maintenance. A fixed installation that does not move between vessels is preferable. Sensors can be easily checked for function at the dock prior to deployment.

Johny Vanhee (ILVO, Belgium). Summary of the Belgium experiences

We have gathered most of our experience while giving advice on board of commercial vessels and we have been taken in account the remarks of fishers. During a period of thirty years the evolution was from apparatus with cables (netsondes), to the first cableless apparatus. The increasing need of more and more data and also the evolutions in electronics forced us to follow technical changes. We first used SCAN-

MAR, and also some fishers do use it. Recently we tested out a version of the Canadian firm NetMind. It had its advantages (low price) and disadvantages (not always functioning). In future we are considering what we are using as net monitoring system. We envisage an easy operating system also from a point of view of software.

A comment was made that acoustic sensors have a time delay following transmission where they cannot receive an echo return, a condition known as "ringing." In low-opening trawls, the echo return may not be received because it returns to the sensor too quickly. Also, it is more difficult to generate consistent readings from wing sensors. Attachment suggestions include tying them tightly to the warp or headline to avoid twisting. It was also observed that the number of good readings can decline during a day or deployment as the trawl may be twisting up at the sensor mounting point.

Further information on battery characteristics was provided. Batteries develop gas, and increase pressure within the sensor possibly leading to cracks because the compartment is sealed. Lithium ion batteries do not develop gas, and have an extremely long life. However, they are expensive and have memory issues: they must be cycled (i.e. completely drained) if too-frequent recharging occurs or charge duration is reduced. This requirement is true of current battery packs and is less of an issue with the Lithium Ion packs.

15.6 Integrated, custom sensor data collection systems

Phil Copland (Marine Laboratory, Aberdeen). Net monitoring equipment used by Marine Laboratory.

The Marine Laboratory suite of sensors, including SCANMAR and ITI sensors, was detailed and examples of typical sensor deployment for survey and gear cruises were shown. Examples of net monitoring vehicles were shown with a detailed list of camera systems used on them or on the net itself. Development of the RCTV vehicle was detailed with reference to the use of fibre optic tow cable and multibeam sonar systems. The RADOS software, developed in the Marine Laboratory, was demonstrated. It has been designed for collection of net parameter data from acoustic sensors. The system has been used mainly with SCANMAR systems but it is easily adaptable for any system generating NMEA strings. A proposed development using a multiplexer system on the headline linked by a netsonde cable to the vessel was discussed. The system could be used to transfer video information from multiple net mounted cameras as well as controlling net mounted lighting and pan and tilt units.

It was questioned whether symmetry information was truly useful because it isn't currently accepted by IBTS group as not everyone has the facility to use it to correct the trawl direction with regard to the flow.

Antonello Sala (CNR-ISMAR, Italy) *ConTrawl*: trawl gear monitoring system

ConTrawl is a complete system for the data acquisition, post-processing and analysis of the main trawl gear parameters. The main measured parameters are: vessel speed relative to the seabed measured by Atlas Doppler log; RPM; shaft torque; shaft power; and fuel consumption of the main vessel engine. Gear parameters include warp loads; horizontal door spread; door pitch and roll angles; horizontal net opening; vertical net opening and clearance; depth, temperature, pitch and roll at the headline centre; trawl speed sensor (longitudinal, transversal speeds); tensions ex-

erted by the warp and by the backstrops at the attachment points of the door; tensions ahead of the net wing tips.

All the instruments are linked by RS232/485 serial ports to a personal computer, which automatically controls data acquisition and provides the correct functioning of the system in real time through an appropriately developed Microsoft Visual Basic 6.0 program. The laptop records on the hard disk all the measurements made at a rate of every ten seconds. Sets of measurements are recorded for every haul to be processed thereafter. The program can average the data and provide such means to a customized database for the standardization of the catch data and calculate the catch rates at species level (N/m^2; kg/m^2; N/m^3; kg/m^3).

15.7 Calibration and sensitivity

Antonello Sala (CNR-ISMAR, Italy), Calibration is Key

A brief overview of the calibration procedures was also provided. For example, for the calibration of the strain gauges, an Instron 4505 universal testing instrument has been used. For the calibration tests, the cell used had a maximum load capacity of 100 kN.

In discussions following the presentation, it was suggested that calibrating along the working range instead of across the total range might be useful. Some participants in the group do not check sensors for accuracy. A simple system, using a mobile hydrophone, was described as a way to test for sensor operation. Time flags and speed through water, and the shape of the actual pulse in a sensor were also discussed. More openness and honesty about the accuracy of the measurements, including the careful use of significant digits was requested. Possible simulation of sensor ranges was discussed; trawl sensor response can be simulated in the laboratory using a delay based on 1500 m/sec as the speed through water. Strange door reading may be multipath readings, especially in shallow water where bouncing off the surface is possible.

15.8 Areas for further development

Gerard Bavouzet (Ifremer, France), Sensor data needs

Data requirements demand sensors defined by scientists and manufacturers. Data must be available in real time or thereafter. The following parameters must be considered:

- Calibration and control of sensor
- Real time data acquisition with real time data
- Acoustic interval transmission if real time monitoring
- Internal high capacity data storage
- Long rechargeable battery life
- Communication for configuration (frequency, gain?), calibration sensor, data records
- Durable, robustness
- Upgrade possibilities of firmware and software
- Open system for optimized maintenance
- Training courses

- Good quality/price ratio

A complete description of each required measurement or sensor (mono or multi parameters) has to be made in collaboration with manufacturers to produce realistic specifications of what is possible under current capabilities or to guide the research and development of further capability.

15.9 Discussion and conclusions

Following discussion, the group concluded:

- Scientific use of net mensuration and other sensor systems requires more communication and understanding between manufacturers and system users than commercial use.
- Systems include different capabilities, and limitations, that should be understood by users before and after purchase.
- Sensor systems require continued maintenance and technical support post-purchase
- Knowledge of sensor accuracy was generally emphasized by the topic group.
- Accurate calibration of net sensors is necessary for scientific rigor.
- Communication between scientists and manufacturers in this forum has been instructive and helpful.
- A continuing need for additional measurement of trawl functions and gear modifications requiring additional sensor development was found.

15.10 Recommendations

WGFTFB agreed the following recommendations:

- Development of a general sensor that accepts input from unspecified non-manufacturer sensors and communicates the data (e.g. voltage) to the surface via the acoustic link;
- Development of sensors with high speed internal logging that is stored and can be offloaded at the surface, that also transmit mean values at regular intervals during data collection;
- Expansion or customization of export telegrams to include ancillary sensory imports (i.e. wire length, tension and surface temperature, and others) that are interfaced with the primary system;
- Optional provision of output data in a simple text format with standard syntax, date and time, in real time or afterwards. Time stamps used in any data collection should be synchronized to a GPS time source only if the data collection is carried out by means of more than one computer;
- Manufacturers are asked to present to researchers a detailed description of system accuracy in each part of the sensor function. In acoustic systems this description would be from data collection at the sensor through to reception at the receiver. Communication of mutual issues concerning accuracy and measurement by sensors, including adjustment for the effect of temperature on the speed of sound through water continues to be an area which could be improved;
- Manufacturers should provide information on test procedures for sensors.

- Manufacturers should continue to emphasize and to provide adequate training for users to allow them to understand system use, function, and limitations.
- Continuation of dialogue between scientists and manufacturers to respond to developing sensor needs;
- It should be recommended to any researchers undertaking trawl mensuration that temperature information should be collected during all hauls at the depth that the trawl is operating. This information will allow correction for calibration changes in tension units and also speed of sound in acoustic measurements;
- The group should reconvene at the Fishing Fair in Ancona in May 2011 with financial support from CNR-ISMAR to discuss innovations in fishing gear and mensuration equipment and to continue to work on the terms of reference.

16 ToR d): Innovation in Fishing Gear Technology

16.1 General overview

Innovation leading to effective technological improvements to fishing gears requires a range of skills, resources and experience that may not necessarily be available from either fishers or governments. Interactions between these groups can determine the success of both development and implementation of resulting technologies. As WGFTFB members have experience in a wide variety of such projects, it is useful to examine and compare these projects to identify factors important to successful development and implementation. Potentially important factors include motivation for pursuing developments, roles of scientists and fishers, communications (both within project and to the larger community), sources of project support, project staging, and mechanisms for implementation.

A WGFTFB topic group of experts was convened to address the issue of innovation in fishing gear technology and the success of collaboration between fishers and scientists with the following terms of reference:

16.2 Terms of Reference

1) Review current technological developments and initiatives in gear technology and give examples of successful developments both in the EU and in other countries globally.

2) Discuss the contributions of fishers and scientists in the process of collaboration and identify conditions allowing rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects.

16.3 List of Participants

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16.4 General Issues

Bob van Marlen introduced this ToR at plenary. The subgroup then met 2 - 3 June 2010. First national presentations were given on innovative projects involving partners from the fishing industry with comments on the cooperation, the results and the rate of success in these projects. A summary table was made up of these projects indicating nation, project acronym, objectives, where the initiative came from, drivers, partners, duration, budget indication, major financers, methodology used, ways to compensate fishers for their inputs, forms of communication, products that resulted, present state, success rate, and comments. This table is included in Annex 9.

Based on this table the discussion focused on critical success factors in innovation. The rate of success was scored 0 to 5 with 0 as no uptake at all, and 5 meaning full uptake in a commercial fishery. Most projects fell somewhere in between full implementation and no implementation, with most having uptake at some level. Innovation is a continuing process, and in many cases improvements are to be expected, even in existing gears. This information is also presented in Annex 9.

Based on a publication in the 1988 fishing gear and fishing vessel technology symposium at St Johns, Newfoundland, a working scheme to chart the progress of gear development was presented by Bob van Marlen. Assessment of other ecosystem components was added as shown in Figure 11.

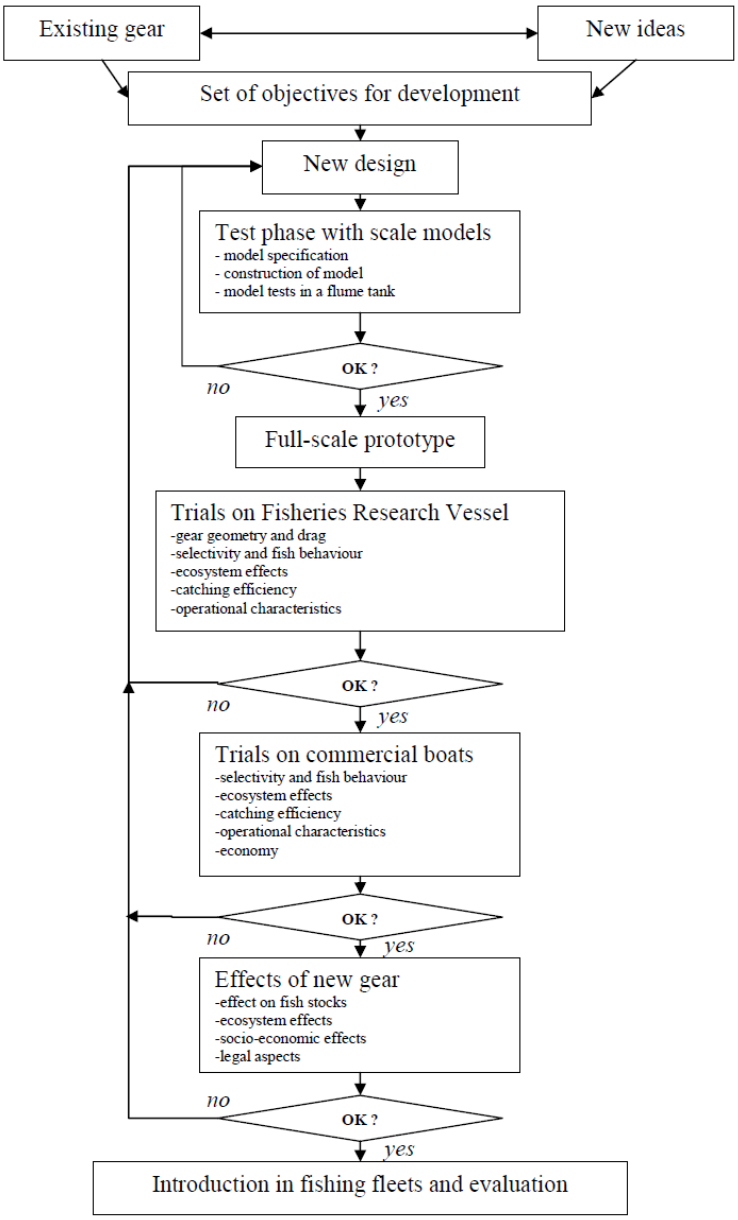

Figure 11. Fishing gear development scheme.

16.5 Individual Countries

Innovative projects from a number of countries were described to illustrate the nature of research completed or ongoing.

16.5.1 Netherlands (Bob van Marlen, IMARES)

In the Netherlands a number of industry/science projects have been undertaken in the last couple of years. These projects have been largely driven with industry needs to solve problems and clearly demonstrate innovative approaches by fishers. Many of these projects have been developed under the Dutch Fisheries Innovation Platform (VIP). These projects include the following:

Project: VIP SumWing

Comparative fishing trials were conducted on a beam trawler fishing with SumWings and a conventional beam trawler towing on parallel courses for a two week period in October 2008. The catches of both vessels were not significantly different, and the reduction in fuel consumption was 11% with the SumWing. The integration with pulse trawling promised further savings in fuel consumption (van Marlen *et al*., 2009b).

Project: VIP HydroRig

This project started in 2008. The objective is to replace the effect of tickler chains by water flow stimulation as shown in Figure 12. First attempts involved a wing-shaped beam deflecting the flow to the seabed. Later spherical cups were used to generate vortices in the wake. Laboratory tests at Deltares, Delft, Netherlands in 2009 showed their potential. Sea trials were positive at first with reasonably good plaice catches and considerably fewer benthic organisms. Comparative fishing trials with direct observation were done in May 2010 in collaboration with ILVO Ostend Belgium.

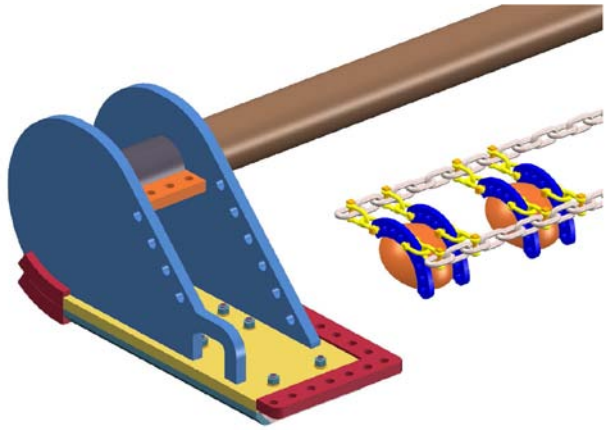

Figure 12. New design of HydroRig to be tested in 2010 (Source: R. van Urk, VCU-TCD Urk).

Project: VIP Outriggen 2008

Two commercial beam trawlers fished with so-called 'outriggers', small nets with otter boards replacing tickler chain beam trawls. Catches and bycatches were monitored in 2008 and 2009 in cooperation with ILVO Ostend. The method can be used to save fuel, and catch 1.4 times more plaice (*Pleuronectes platessa* L.). Catches of sole (*Solea vulgaris* L.) were considerably lower (16%) despite attempts to bring them to higher levels. Fuel consumption was reduced by 55%. However, using 80 mm codends can give high levels of undersized fish bycatch. More details can be found in (van Marlen *et al*., 2009c).

Project: VIP Passive Gear Development

A new project was started in 2010 with three vessels operating passive gears with the objective of developing year-round fishing opportunities for vessels using static gears. A separate research programme was set up for each boat testing gillnets, trammel nets, pots and jigging machines. Data will be collected using a predefined format and analysed by IMARES. Experience in Belgium (through ILVO) and Denmark will also be sought.

Project: VIP ViBOS

This project aims at developing a data collection and decision support system for fishers. Three beam trawler skippers are involved. The project is coordinated by Chartworx Ltd. of Den Helder, the Netherlands. We aim bringing together data from various sources, e.g. DGPS, electronic sea charts with hydrographical data, vessel plotter, catches and bycatches (E-logbook), warp loads, fuel consumption, etc. The system will be made to optimize the skipper's performance in terms of catches, fuel use and effects on the marine ecosystem.

Project: VIP Industry Survey: Phase 1

In 2009 the first phase of the Trajectory Industry Survey was carried out whereby fisheries managers, fishers and fisheries scientists investigated whether an industry survey, in addition to research surveys, would be useful in assessing plaice and sole stocks. How such an industry survey should be set up and how it may influence fisheries management is being investigated based on similar initiatives in other countries.

The first phase showed that comparative fishing between research vessels and a commercial vessel is feasible and that there is sufficient support for an industry survey from (international) scientists, fishery managers and fishers. A request for funding of phase 2 was submitted in March 2010. In that phase the comparison of length frequencies of plaice and sole will be finalized.

Other Projects

In addition a number of projects have been completed in the Netherlands which also have had a high degree of industry input. These include:

- Project: ICES research on pulse trawling
- Project: Bycatch Reduction by Technical Means (Dutch: VDTN-3)
- Project: Energy Saving In Fisheries (ESIF)
- Project: Flatnose (FISH/2007/07 LOT3)
- Project: Development of fishing Gears with Reduced Effects on the Environment (DEGREE)

Details of these projects can be found in Section 19.6 in the National Report for the Netherlands.

In addition to these projects a number of industry networks have also been created to address fishery issues, provide a mechanism for fishers to input into the development of stock assessment surveys and also to generally improve dialogue between fishers and scientists. These include the following:

Project: Cooperative Research Platform

This project is all about cooperation between the Dutch Ministry for Agriculture, Nature and Food Quality, the Dutch Fisheries Product Board and IMARES. This was set up in 2008. In the platform representatives of the fisheries, managers and scientists participate with the common objective of coordinating all ongoing projects that are relevant to management and to share information. Several issues are being dealt with in the Cooperative Research Platform, e.g. validity of research surveys, collaboration in discards monitoring, setting up an industry survey etc.

Project: Fishery Study Groups ('Knowledge Circles')

Fishery Study Groups are (study) groups of fishers who formulated challenges, questions or problems in their fishery. Together they look for solutions to make their fishery more sustainable: both from an economic and ecological point of view. There are currently 13 groups of fishers, working on various fisheries in the Dutch sea, lakes and rivers. Issues that are being dealt with are e.g.: gear development (pulse trawl, SumWing, outrigger, fly-shooting, static gear, *Nephrops* trawl and shrimp (*Crangon crangon* L.) trawl), reduction of bycatch or discards, increasing knowledge of target species, reduction of fuel costs and improving cooperation between fishers and retailers.

16.5.2 Belgium (Christian VandenBerghe, ILVO)

Outrigger:

Beam trawling has been under pressure due to fuel costs and the high consumption of materials. Therefore there have been concerted efforts in Belgium to develop solutions for the beam trawl fleet. The outrigger trawl was introduced as a cheap replacement because it can be used on the same vessel without high investments in new gear. The heavy beams were replaced by much lighter otterboards and the chain weight was reduced by 80% (Figure 13).

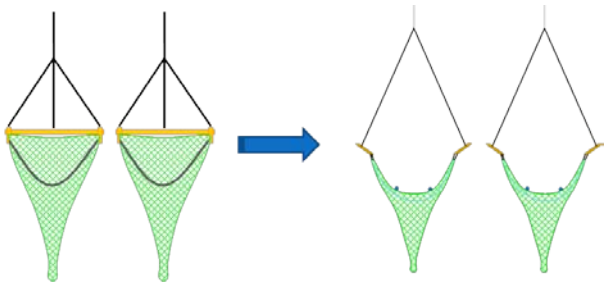

Figure 13. Dual beam trawls compared to outrigger gear.

A project was setup with the industry as a partner and was funded by the Flemish government and the EU. The first phase was an experimental phase where the gear was fully developed through initial flume tank testing. This allowed testing of different techniques suitable for different fishing grounds (tested different trawl doors) and different species (adjustments to the rig). The second phase was to demonstrate the technique to industry. Ship owners were informed and volunteers where sought to try out the technique facilitated by industry experts. The results were promising with fuel costs decreased by up to 70% and fish quality improved. Outrigger has been taken up by a number of vessels and is still being used.

SumWing:

The SumWing is being used in the Netherlands for a few years now by beam trawlers fishing with tickler chains and has plaice and sole. The main goal is to reduce fuel consumption and reduce the environmental impact. Three sets of SumWings where bought by the industry and tested by several Belgian beamers. After solving some technical problem fuel savings of up to 17% have been demonstrated and a s a result of this technology transfer 12 large beamers in Belgium now use the SumWing

Alternative beam trawl:

The alternative beam trawl holds a combination of selective devices in order to reduce discarding and reduce the impact on the benthic ecosystem. Among the options are: inclined separation panels, T90 codends, large meshes in the top panel and roller gear. There are a number of benefits to the alternative beam trawl including shorter sorting time, due to less bycatch and therefore the possibilities of longer hauls, as well as less wear to the gear. The alternative beam trawl is now recommended by the Belgium authorities as not only as a gear but also as a concept where skipper and crew become aware of the beam trawl "problem" and act as responsibly.

Passive fishing:

This project aimed at testing different passive gears to collect knowledge so support could be given to fishers who would like to switch from trawl fisheries to passive gear. Our practical experiences with a variety of gears could also increase flexibility. The reduced costs associated with these fishing methods are the main benefit for fishers. In addition, the lower benthic impacts give a positive public perception, which is becoming of increasing importance in Belgium.

Several gears were tested on different fishing grounds and different species (Figure 14) including gillnets for turbot and brill in the North Sea, trammel nets for sole, turbot and cuttlefish in the Celtic Sea and North Sea, pots for cuttlefish and whelk in the North Sea as well as angling for sea bass. Every tested gear seemed to work accept for the whelk pots. The three ships doing the experiments bought the gears and in the mean time 4 vessel owners sold their beam trawler and switched to passive gear.

Figure 14. Static gear used in Belgium.

Hovercran:

HOVERCRAN is a new type of shrimp fishing gear that aims at stricter selectivity and reduced seabed contact (Figure 15). The objective is to replace the heavy bobbin groundrope traditionally used with electrodes to generate electric pulses as a stimulation alternative (Figure 16). Research by ILVO has shown that the use of a specific electric field close to the seabed induces a startle response in shrimp and leaves other organisms untouched. Herein lays the selective fishing potential of this alternative technique. In addition, exposure and survival experiments, carried out in cooperation with the Ghent University, have shown that the use of these pulses, low in frequency and voltage, has no significant effects on fish and invertebrate species.

Preservation of the commercial catches and the reduction of discards and seabed contact are the decisive criteria in the evaluation of the HOVERCRAN. Preliminary testing of the prototype on a commercial shrimp cutter, by direct catch comparison with a standard shrimp trawl, revealed important and encouraging results. First and

foremost it can be shown that at least as much shrimp can be caught with the new technique compared with the traditional gear. In addition an average bycatch reduction of 35% in volume and a reduction in bottom contact of ~75% have been demonstrated, improving the environmental performance of this gear markedly.

At the moment ILVO and IMARES are setting up a new test phase in collaboration with the Dutch shrimp fishery. A year-round assessment of an optimized prototype on two cutters, operating in the Wadden Sea, will hopefully reveal if the technique is feasible under commercial circumstances. These trials are financed by the Dutch shrimp fishery and the Wadden Sea Fund.

Figure 15. HOVERCRAN construction and catch examples.

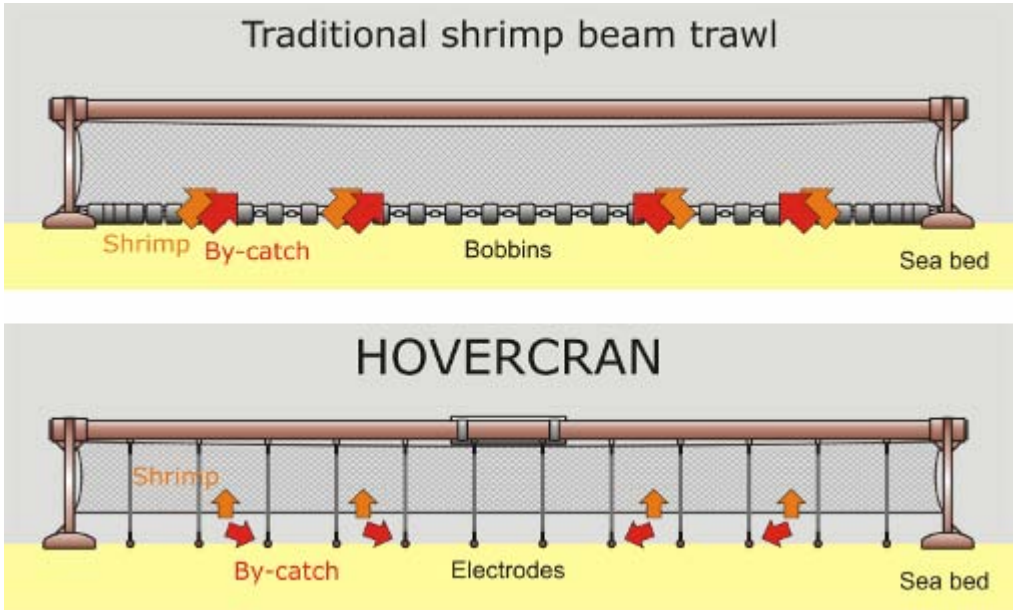

Figure 16. HOVERCRAN working principle.

16.5.3 Spain (Juan Santos, IEO)

Project: PSE_REDES

PSE_REDES is a recently funded strategic Spanish project relating responsible fishing to discard reduction. The project identifies fishing gear modifications on a fishery by fishery basis. Five linked subprojects have been established in order to integrate with each case study stepwise. One of these subprojects includes the setting-up of a so-called "Design Centre". This is a meeting point between scientists, technicians and fishers, aiming to create a collaborative environment for the process of design and construction of selective fishing gears and devices. It is expected that the participa-

tion of fishers will increase the chances of adoption of the selective gears by the commercial fleets. Results from the analysis of the major effects expected from the potential introduction and spread of use of selective fishing gears will be reported to the fishers.

16.5.4 Sweden (Hans Nilsson, IMR)

During the last decade the use of the "Swedish grid" has increased in the Swedish *Nephrops* trawl fishery in the Skagerrak and Kattegat. In 2009, 61% (650 tonnes) of the total landings from the *Nephrops* trawl fishery came from vessels using the grid (Figure 17). The original objective in developing the grid was to exclude cod. The cod stock is assessed as being in a very poor state in the area and in order to protect it, the border where the trawl fishery is allowed was moved outwards from the Swedish coastline. However, in the area between the new and the old border some large *Nephrops* fishing grounds were located and to minimize the effect on the industry, vessels using the grid were permitted to trawl in parts of this area, since the bycatch of cod was demonstrated to be less than 1.5% of the total catch. In 2008 the fishery department was approached by a fisher who wanted to go further and minimize the catches of unwanted *Nephrops*. This was the first step in the development of the "VIDRIST", a two panel grid with a lower grid panel (22 mm) size selecting *Nephrops* and an upper grid panel (40 mm) excluding cod (Figure 18). The preliminary results from sea trials with the "VIDRIST, 22/40mm" look promising with significantly decreased catchability for small *Nephrops* and increased catchability for the larger *Nephrops* compared with the standard Swedish grid (38mm, Figure 19). The increase in catchability for larger *Nephrops* was found to be dependent upon increased bar spacing – 40 mm instead of 38 mm which is standard in the original grid. The question that still has to be scientifically answered is if the increased distance between bars from 38 to 40 mm in the upper panel will increase the bycatch of cod above the 1.5% limit, as per the regulation for the Swedish effort exemption under the EU LTMP for cod.

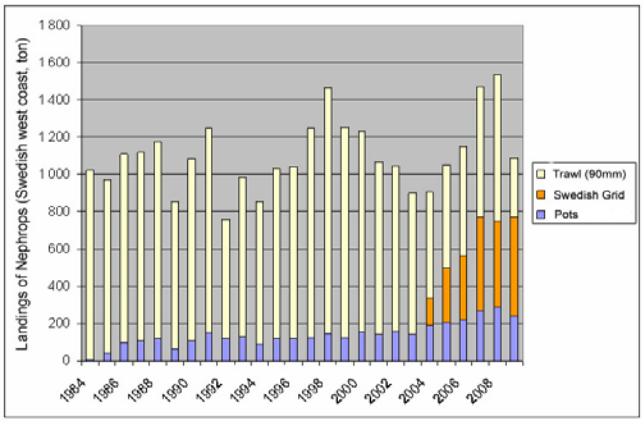

Figure 17. Landings of Nephrops from different fisheries along the Swedish west coast between 1984 and 2009.

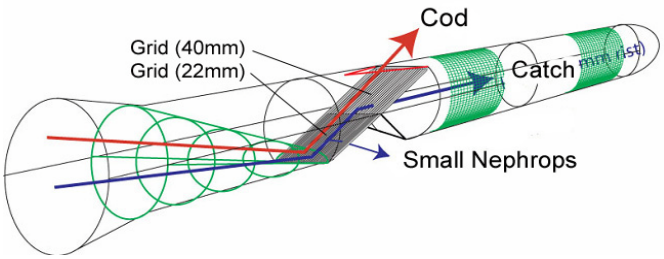

Figure 18. The principle drawing of the "VIDRIST".

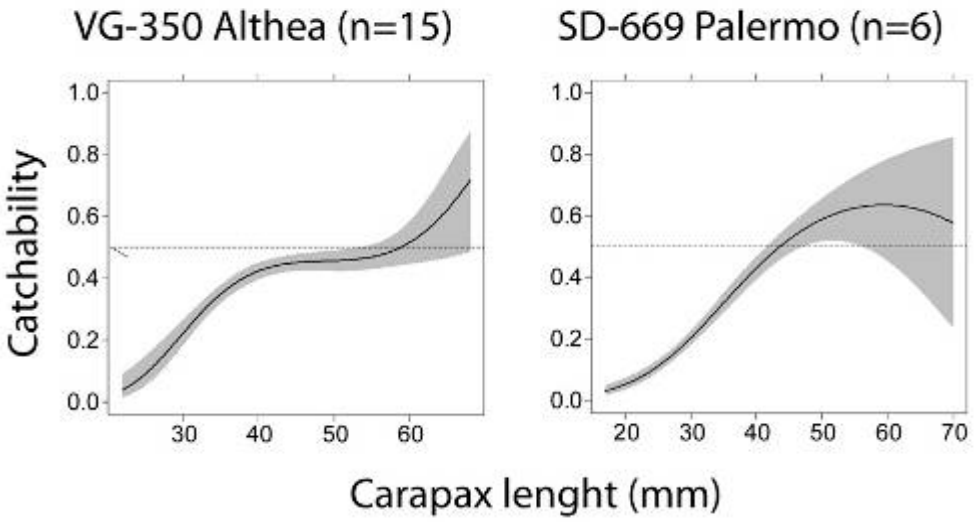

Figure 19. Size selectivity of Nephrops in a twin trawl sea trial setup on two different commercial fishing boats "Althea" and "Palermo". The size dependent catchability by the VIDRIST (22/40 mm) compared to the Swedish grid (38 mm).

16.5.5 France (Pascal Larnaud, Ifremer)

16.5.5.1 Collaborative and innovative projects on selectivity

Many trials have been carried out by Ifremer since its creation (and previously by ISTPM) in partnership with fishers. From the "fishing more" attitude which ended roughly in 1985, the focus in this collaboration has shifted recently to "fishing better". In 2002, a strong collaborative project, between fishers and scientists, called ASCGG (Selectivity improvement in Nephrops fishery in the Bay of Biscay) evolved. It resulted in more than 2000 hauls conducted on-board commercial vessels with new selective devices. Thanks to this collaboration the use of a 100mm square mesh panel on the top of the extension piece in the Bay of Biscay was included in EU regulations. It also confirmed the benefit of a flexible grid for *Nephrops* selection. A lot of work has been carried out since this project, in partnership between scientists and fishers to improve existing selectivity devices and design new ones. The NECESSITY EU project actively contributed to these developments, through the test of side escape square mesh panels and of the combination of square mesh panel with a *Nephrops* grid. It was followed by a study lead by AGLIA (Inter-regional Organisation which interfaces between fishers, scientists and stakeholders) in partnership with Ifremer, on various selective devices in the *Nephrops* fishery. These included increasing codend

mesh size to 80mm, *Nephrops* grid and square mesh panel positioned in the bottom sheet. The choice of one of these three devices is now mandatory in the Bay of Biscay. A last joint AGLIA and industry project, SPD project (Selectivity for sustainable fisheries), has now commenced. The ongoing experiments aim to decrease drastically discards rates of fish and *Nephrops* in the mixed fishery of the Bay of Biscay. The procedures of all these studies, funded by the EU, State and Regional Councils, is more or less similar, manufacturing small-scale selective nets after discussions with the fishers, which are then tested in flume tank; the best experimental trawl designs are then tested at sea on an Ifremer research vessel. The results of the sea trials are discussed with steering committees involving fishers, scientists and Fisheries Authorities in order to agree and select the devices that will be tested on a group of commercial vessels for a representative number of days at sea. Data collection on the commercial vessels is carried out by observers financed by the projects. The data are then analysed by Ifremer and discussed with the steering committee.

Recently, the SELECMER project aimed at reducing significantly discards of undersized whiting in the fish trawl fleet operating in the southern North Sea and in the eastern area of the Channel, was finalized in 2009. It was implemented by industry stakeholders in partnership with Ifremer; the initial request came from the Fisheries Authority who wished to make an agreement with Norway on reducing whiting and cod discards (this is also the main driver for the SELECCAB project hereafter). Funding came from both the State and the EU. The SELECMER study showed the benefit of a flexible grid with 23mm bar spacing with an escapement rate of 30% of the small whiting below 22cm and 50% of plaices below 27cm. Nevertheless, these results have to be improved to optimize whiting escapement up to the legal size of 27cm and the trials will continue in 2010 within the new SELECCAB project. This latest project aims at improving the selectivity of both whiting and cod. New designs of trawl gears with large meshes and selective grids have been made in 2009 based on numerical simulation and flume tank trials.

Other technical studies on the improvement of the selectivity of shrimp trawls were completed in French Guyana and in Madagascar (different Bycatch Reducing Devices, TED-Turtle Excluder Devices). The working methods described above were also applied in these projects. In both cases, the initial request came from the fishermen's associations. Concerning TED's, in addition to environmental concerns, an important driver was the requirement to use a TED to get a certificate for exporting shrimps to the USA. It is interesting that the first trials on TED's in French Guyana were in fact financed by a NGO.

16.5.5.2 Collaborative and innovative projects on alternative fishing gears

Partnerships with fishers have also been found important in France in research and development of fish pots. A first project, ITIS SQUAL, certified by the Brittany Sea Pole of Competitiveness, started in 2007 and ended recently in 2010. Together with a local netmaker, 5 prototypes of fish pots were designed and tested in flume tank. Preliminary trials at sea were then conducted during spring 2009 in order to assess the handling and efficiency of the newly designed gears. The performance of the 5 models was assessed and compared. The results were presented to the industry and discussed in order to initiate a wider use of passive gears among fishers. A first set of these fish pots and *Nephrops* traps had been bought by Ifremer and lent to fishers to voluntarily test them along the French coast. ITIS SQUAL project was initiated by Ifremer to answer to a call of the Brittany Sea Pole of Competitiveness and it is financed by the state (FCE – Fund for Enterprises Competitiveness), Ifremer, IMP (In-

stitut Maritime de Prévention) and a net manufacturer. Another project which involves several fishing companies, a fishing gear manufacturer, and institutional organizations, aims at developing fish pots to mitigate against the predation (40%) of toothfish by killer whales and also to reduce seabird mortality, in the Antarctic area of Kerguelen and Crozet Islands. In this project, the work was initiated by the French authorities in the austral seas (Terres Antarctiques Australes Françaises), through experiments with fish pots to solve the problem of toothfish predation and reduce seabird mortality. The project is financed by the state (FCE – Fund for Enterprises Competitiveness), by the fishing industry (SARPC organization), net manufacturing company and the research institutes participating (Ifremer, MNHN – National Museum for Nature History, CNRS – National Centre for Scientific Research). Various types of fish pots have been designed or sourced from other areas, both floating and static. Floating pots were initially tested in flume tank. Tests at sea were carried out during a 45 days trip on a commercial vessel in January/February 2010. The measuring equipment and video systems for observing the behaviour of fish in and around the pots were operated by Ifremer.

16.5.5.3 Collaborative and innovative projects on energy savings and bottom impact

Other important fields of study in France, as in many other countries, concerns energy savings and impacts on benthic habitats; both are linked as impact will often decrease when improvements are made to save energy (decreasing drag enables the use of smaller and lighter doors or lighter footropes). Several projects have been carried out, the first is the CHAMAD project in Madagascar, carried out on the request of the shrimp fishermen's association (GAPCM) and funded by the AFD (Agence Française de Développement). Through numerical simulation, flume tank testing and trials at sea on commercial shrimp trawlers, this project permitted fuel savings of 20%. Similar projects have also been carried out in France. In Brittany for example, a 'semi-personalised' diagnosis of Breton trawlers, managed in partnership with Brittany regional fisheries committee, was carried out in cooperation with several gear manufacturers. The results achieved were presented to the industry as well as to the Economic and Social Council of Brittany. The study resulted in a potential saving in energy consumption of 5 to 17% for the total fleet (depending on the size of the trawlers). For a new complete fishing gear, the investment can be paid back within 3 to 40 months, though most of the time this was found to be less than a year. The theoretical economic outcomes achieved with the numerical simulation tool (DynamiT) were confirmed by measurements at sea on board 3 commercial vessels. In synergy, the OPTIPECHE project permitted the development of a novel type of trawl door in cooperation with the company Morgère. It enables a substantial energy saving (around 25% vs. standard doors, i.e. 5% of the total consumption of a trawler along with reduced impact on the seabed. The industry has received this new type of door with enthusiasm and several boats are already equipped. These two projects were financed by the Brittany Council, by the manufacturers and by Ifremer. Another very innovative trawl door ("jumper" door) was also developed in the European project DEGREE (between 2006–2009, van Marlen *et al.*, 2010). Several reference trawls were also optimized in the European ESIF project (van Marlen *et al.*, 2008; van Marlen and Salz, 2010). Another project is also going on in the eastern English Channel and in southern North Sea to optimize trawls for energy savings (EFFICHALUT). This project resulted from a call for energy savings launched by the French Fisheries Authority (DPMA); this a joint project between local fishers organization (CME) and Ifremer.

16.5.6 USA (Craig S. Rose AFSC, NOAA)

Development of trawl modifications to reduce salmon bycatch in Alaska pollock fisheries began with video and sonar observations to evaluate behaviours of target and bycatch species in pelagic trawls. Observed differences in the swimming abilities of salmon and pollock were exploited in designing prototype excluder devices. Tests of these devices were conducted under fishing permits that provided additional catch to participating vessels and kept associated salmon catch from affecting bycatch limits. Fishermen adopting early devices, following indications of effective salmon escapes, found problems with net damage at high catch rates. Several design changes to prevent these problems either were not effective or substantially reduced salmon escape rates. Recently, building on an innovation from a gear manufacturer, a design has been shown to handle large catches while excluding 25 – 35% of the Chinook salmon.

This project has been led by industry participants, with government scientists providing initial behaviour research, scientific design and analysis, and in situ observation capabilities. Workshops were conducted throughout the project to coordinate efforts and to inform and obtain advice from fishery participants and gear manufacturers. While problems with initial designs discouraged some early adopters, their participation and feedback allowed those problems to be addressed. Limits on salmon bycatch at the vessel level have motivated use and continued improvement of these devices in the pollock fishery.

16.5.7 Poland (Waldemar Moderhak, MIR/SFI)

In Poland there has been a great deal of research and development work into the development of T90 mesh to improve codend selectivity for cod in the Baltic Sea. The selective properties of a T90 codend depend on the proper shape of the T90-meshes. The mesh opening is determined by the forces acting on mesh bars, and by the twine stiffness (thickness). Based on the opening mechanism of T90 meshes and the cross sectional shape of Baltic cod, it is possible to find the optimal mesh bar thickness that will create the best conditions for release of juvenile and undersized cod. Both at low and at high values of thickness the length of escaping cod is smaller. At low twine thickness the T90 mesh is stretched relative far open, and at high thickness the lengthwise opening is small. (Figure 20 and Figure 21).

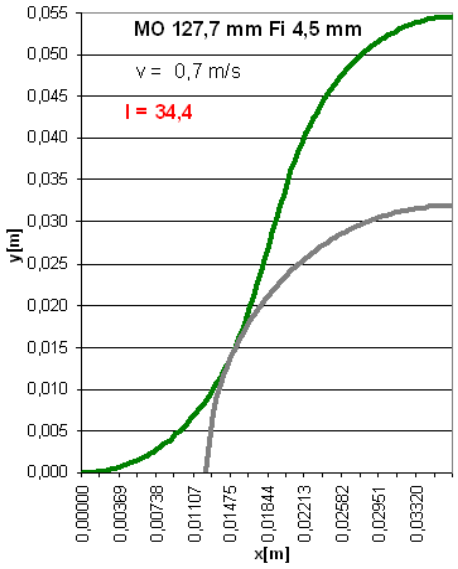

Figure 20. Length that cod can escape from a T90 codend (green is the deformed T90 mesh bar (normal direction) and grey the cross section of the fish).

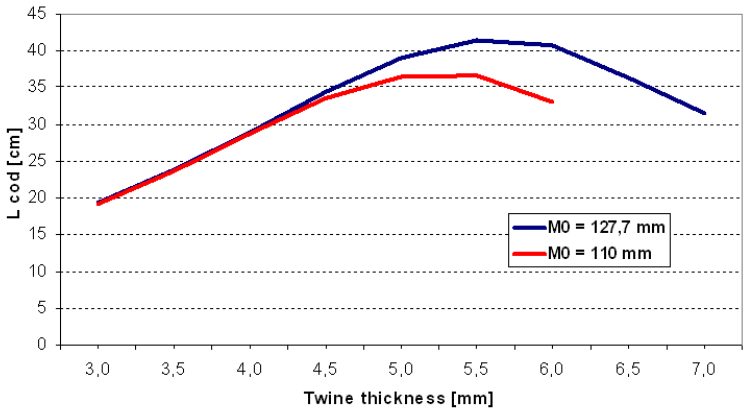

Figure 21. Calculated length of cod vs. twine thickness for T90 codends.

16.5.8 Turkey (Huseyin Ozbilgin, Mersin University)

Investigations to Improve Species and Size Selectivity in Mersin Bay (Northeast Mediterranean) Trawl Fisheries

Mersin Bay is one of the most heavily trawled fishing grounds in the Northeast Mediterranean. According to 2006 data of Institute of State Statistics, number of the trawlers registered to ports of Mersin province (115) represents 15.9% of total number of trawl vessels registered in all Turkish ports (725). In recent years, reduction in catch per unit of effort and mean sizes of the landed products are among the most important problems experienced by fishers in the region. Poor selectivity and low engineering performance of the conventional trawl gears used in this fishery are some of the main reasons of the above mentioned problems. Significant amounts of benthos, rays, sharks, sea turtles, crab, juveniles of commercially important species such as red mullet, sole, and hake as well as litter are caught in trawling conducted in Mersin Bay.

Exclusion of these components of the catch during fishing operation will reduce the damage to marketable catch, sorting time of the crew on deck, and increase the performance of the gear. A nationally funded three year project starting in June 2010 will be conducted in four work packages:

- Determination of species and size groups which need to be excluded from the gear. This information will be obtained from the results of investigation of seasonal variation in catch and discard composition of the commercial trawl fleet.
- Observation of whether this species and size groups show different behavioural responses than target catch during trawling operation.
- Developing designs to improve selectivity (by using sorting grids and/or square mesh combinations), and adaptation of the most selective designs to trawl gear. Selective designs will be formed by evaluating the data from the first two work packages of the project, literature information, and opinion and criticisms by experienced fishers.
- Introduction of the selective design to the fleet.

During the three year period 201 days of work at sea, and 40 days of seminars and workshops are planned. Development of a selective gear design and its acceptance by commercial fleet are the most important goals of the project. In the case of achievement of positive results in these targets, the project has a potential to be the first example for not only Turkish but for all Mediterranean trawl fisheries.

16.6 Main Outcomes

Factors determining the outcome of innovative projects were summarized as follows as shown in Table 9.

Table 9. Summary Table of how to determine the outcome of innovative projects.

FACTOR	IMPORTANCE	COMMENTS
Objectives (clear, understood by partners, agreed upon)	high	One should at least understand objectives, and not necessarily agree on all.
Drivers and motivation (economy, ecosystem concern, low stock sizes, markets, loss of opportunities for landing)	very high	One needs the motivation to get to any success at all. Motivation should be strong, but it is not so important what it is. Political pressure and low image may also motivate, e.g. bycatch of marine mammals. The threat of areas being closed is another example of a strong motive to change. Getting rid of seals as competitors may be one (Baltic). There may be differences between skippers and crew members, depending on ownership of the boat. Fishermen organizations can play a role in convincing people and improving motivation. One has to believe in it to make a project successful.
Initiator (scientific community, industry, government)	Very high or low depending on view point	If fishers feel that they own the problem they are more motivated. Telling them what to do does not work, and especially not when this comes from non-fishers, biologists or even civil servants. Ideally it should not make a difference.

FACTOR	IMPORTANCE	COMMENTS
Finance (e.g. EU, national government, product organizations, private companies)	Very high	There are examples of innovations paid by fishers themselves, but at some stage they wonder: why should I pay and others get the profit later? Projects at sea are costly. Funding should leave room for own investments to keep people motivated. Some commitment on behalf of fishers on financial resources is critical. Experience of Dutch skippers indicate that ideally more than 1 vessel should be involved.
Duration (short, medium, long)	medium	Sometimes a 3 year project just give first results, and often follow-up work is needed (e.g. NECESSITY). When fishers can use their vessels the work is more intense with perhaps quicker results. Too short is not good, but too long neither. At least a couple of years are needed.
Methods and facilities used (e.g. flume tank models, research vessels, commercial vessels, direct observation techniques, gear measurements)	medium	All these facilities are often used, also by fishers themselves, e.g. flume tanks and underwater cameras. Research vessels may be included, but mostly commercial boats are used. During initial stages working on a commercial boat trying to make money is not such a good idea. It is a matter of stage in the project. Research boats often offer more space and the possibility to work without pressure to earn from fishing. Use the right facility at the right time.
Project organization and control (steering, budget control, objective oriented, communication)	high	As in any project these conditions should be met well. Steering is needed and aim to be kept in mind, but not too rigidly. Sometimes it pays of to let fishers pursuit with their ideas instead of trying to convince then against odds. Postponing a decision may also help.
Communication (internal, external, style)	Very high	Good experiences are found e.g. with making a DVD showing the cooperation. Underwater sequences are often appreciated very much by fishers, short sequences are already sufficient. Language issue is a point, scientists speak differently. Invitations to fishers to conferences are appreciated. A different language is not a sign of disrespect. Choice of dates for meetings taking account of fishers's limitations can be important. Invitations to teachings at a university might help to give them the feeling of being part of it. This also applies to inviting fishers on trips on research vessels.
Effectiveness of result to meet objectives	high	Best to meet original objectives, but there may be other things to be gained.
Acceptability of result to fishers	Very high	Results must work on a fishing boat under practical circumstances. Should also be economically viable.

FACTOR	IMPORTANCE	COMMENTS
Acceptability of result to society (e.g. NGOs)	high	True if objective is something pushed by the NGOs. Issues are often advocated, perhaps strongly and very focused. From reactions by skippers one sees increasing awareness of this influence. How you bring it may become more important.
Mechanisms for implementation (regulations, benefits, e.g. more days-at-sea, access to grounds, price competitions and rewards, better image)	high	Regulations are seen to becoming too complex and too much detailed and unpractical, at least in Europe. Abilities to continue fishing are all important. Should be tuned to individual vessels if a change in behaviour is to be seen.
Mechanisms for facilitating research (prototypes given out, research vessel time, scientific quota, training, provide underwater camera systems for use)	high	Lowers thresholds for fishers to be involved in research activities.
Roles of participants (competitive, complementary, practical inputs vs. scientific methodology (data collection and analysis, statistics)	high	Recognizing what each brings to the table and respecting this is vital. There is a role for cross-teaching as well.
Mutual understanding and trust (openness, attitudes, atmosphere)	Very high	Trusting one another is a vital element.
Relation of project outcome to rule setting and enforcement	high	Often one reacts strongly and says that one should not be penalised for collaboration.
Project leadership (style, effectiveness)	Fairly high	Ties in closely with project organization and other aspects. Lack of leadership can be a problem. there is a subtle balance between too much control and too little.

16.7 Conclusions

The Group concluded the following:

- Innovation is definitely needed for fishing industry to survive.
- Innovation needs strong motivation and clear objectives. Incentives are generally related to finding ways to continue fishing, e.g. access to grounds closed without taking measurements, more days at sea, better economy, e.g. lower costs (fuel).
- Results should be practical, meet the objectives and work well on a fishing boat under commercial conditions, without incurring great losses in income for fishers.
- Mutual trust and respect of project participants are vital for success. Open and effective communication is needed.
- Ample finance should be given, projects at sea are expensive, and results not expected in a few months. At least a time span of several years will be needed.
- A proper working methodology enables good results and facilitating fishers being engaged in research activities is necessary.

- The outside world is becoming more influential, e.g. NGOs and fish retailers. Market forces can provide strong motivation for change.
- It helps when fishers see the problem as their own and can identify themselves with the objectives and the contents of the work and the solutions emerging from it.
- Fishermen should not get the feeling of being penalised for openness and cooperation. Regulations should make sense, be practical, not too complex, and enforceable.

16.8 Recommendations

WGFTFB recommend that this Topic Group meet again next year and extend the table of innovation projects with more information from other countries as well as updating project outcomes.

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17 WGECO/WGFTFB framework for analysis of gear based technical measures

17.1 General Overview

In 2008 WGECO, in conjunction with WGFTFB, began the process of developing a methodology to assess and quantify the efficacy of Gear Based Technical Measures (GBTMs) introduced to reduce the environmental impact of fishing. An indicative methodology was developed and further modified by WGECO/WGFTFB in 2009. This methodology developed identified the significant adverse impacts (FAO, 2008) of particular fishing gears that should be considered in experiment planning and assessment of mitigation measures. In 2009 the methodology was trialled by working through an assessment of the significant adverse impacts of two specific fishing gears and using the experiences gained to modify the methodology to make it operational. The two case studies selected were flatfish beam trawls in the North Sea and Bottom set gillnets in the Baltic Sea. This analysis was presented to both WGECO and WGFTFB separately for consideration. In general both groups felt that this was a good initiative but a number of concerns were raised particularly regarding the use of Signification Adverse Impact as defined by the FAO. Given the lack of data in many fisheries in some of the ecosystem components using this definition ran the risk that every fishery would be classed as SAI under the precautionary principle enshrined in the FAO definition. It was felt important more specific descriptors of gear parameters are needed or there is nothing in the evaluation to allow for making technical modifications to the gear to mitigate negative actions. It was felt therefore that further refinement would be needed and the methodology developed needed to be tested with some actual gear modifications to see whether it was workable in practice.

At the WGFTFB meeting of 2010 a topic group formed to consider the methodology and using a number of well documented gear based technical measures assess whether their efficacy could be assessed using the methodology. In addition a table showing available instrumentation and instrumentation currently used by gear technologists to measure the impacts of GBTM was also developed as a reference tool. This table is shown in Annex 10.

17.2 Terms of Reference

A WGFTFB Topic Group will be formed to address the following ToR:

1) Taking a well documented gear based technical measure; evaluate whether this measure can reduce Significant Adverse Impact for different ecosystem components using the methodology developed with WGECO and how this can be practically evaluated.

2) If methodologies do not currently exist for some impacts, assess whether any could be developed.

17.3 List of Participants

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17.4 Description of the Methodology and Outcomes from 2009 Assessment

The methodology developed jointly by WGECO and WGFTFB is based around four ecosystem categories (ICES, 2009):

- Commercial fish species – representing any fish landed by commercial fishing
- Listed species including fish, cephalopods and benthos – representing any species previously listed as vulnerable or at risk
- Marine mammals, marine reptiles and seabirds
- Pelagic and benthic habitats and assemblages – representing the habitats and their associated species assemblages including fish, invertebrates and flora.

The outcomes of the two fisheries assessed using the methodology was as follows:

Outcomes – Beam Trawls in the North Sea

The beam trawl fishery in the North Sea is largely carried out in sandy areas. There is evidence of long-term impacts of beam trawling on the physical habitat of the southern North Sea (Lindeboom and de Groot 1998), in particular, related to the removal of boulder fields and oyster beds. In general this can be seen as irreversible, but historic. Current beam trawling is unlikely to cause further change, assuming no change in fishing activity pattern.

There have been long-term changes in benthos species composition as a result of beam trawling. While this may be capable of recovery this is unlikely that the larger long-lived species would be back to their original proportions in the benthic assemblage within 5–20 years (Collie *et al.*, 2000; Kaiser *et al.*, 2006). This community is now dominated by highly productive opportunistic species.

The fish assemblages in the southern North Sea (where beam trawling predominates) have shown substantial and long-term changes that have been well documented (Rogers *et al.*, 1998; Daan *et al.*, 2005).

Assuming natural habitat is defined as former natural conditions; the southern North Sea would be assessed as SAI with high confidence in terms of habitats and associated assemblages.

Outcomes – Bottom Set Gillnets in the Baltic Sea

Based on available documentation (ICES, 2006) the impact from fixed gears on benthic habitats is small, and caused by anchors, weights and groundgear. The largest impacts have been shown to occur when the gear is dragged over the seabed during hauling (Eno *et al.*, 2001). In areas of high habitat structure, particularly biogenic features, the consequences of this can be severe; however, such structures are relatively rare in the Baltic Sea.

In terms of the fish communities, there is no evidence of major impacts from gillnet fisheries in the Baltic. Gill nets are generally very selective, and there are relatively few species present or caught. The primary driver for fish community change in the Baltic is considered as environmental and driven by climate changes (Köster *et al.*, 2005). Therefore gillnets were classified as having NSAI at a high level of confidence.

17.5 Issues identified with the Methodology

When considering the methodology initially in 2009, caution was urged in the use of Significant Adverse Impact (SAI) as defined by the FAO for high seas bottom-trawl fisheries. WGFTFB felt that given the lack of data in many fisheries in some of the ecosystem components using this definition ran the risk that every fishery would be classed as SAI under the precautionary principle enshrined in the FAO definition. This effectively would mean it would be almost impossible to demonstrate that any gear modification could be shown to reduce this impact and so the methodology would be redundant. On further consideration of the methodology in 2010, the group concluded that this remained a fundamental problem which impaired the usefulness of the methodology to gear technologists. Data deficiencies and relevance of certain measures to the ecosystem components were also identified as problems. Overall it was felt the methodology was unduly complicated.

17.6 Case Studies

Gear Based Technical Measures can be divided into gear modifications developed to:

a) Reduce fish bycatch or discards and improve size or species selectivity.

b) Reduce accidental bycatch of protected species.

c) Reduce benthic impacts.

The following three case studies reviews methods used in the past to try to assess the efficacy of particular GBTM that are representative of the above. In describing these assessments attempts were made by the group to illustrate some of the difficulties with the new methodology developed.

17.6.1 Case Study One – Fish Bycatch reduction devices

Globally there have been a myriad trials carried out with GBTM designed to reduce discarding and reduction in the catch of non-target fish species. Generally these studies have been carried out with this principle objective with little or no consideration for other fish species or ecosystem components. O'Neill *et al*. (2008) report on one such set of experimental trials carried out to assess the selectivity of haddock (*Melanogrammus aeglefinus*), cod (*Gadus morhua*) and saithe (*Pollachius virens*) in 120mm mesh codends with (i) 100, 80 and 60 meshes in circumference; (ii) a 35mm 'flexi-grid' mounted in the extension and, (iii) a 110mm 'Bacoma' style square mesh panel.

They then used a stock prediction method of the ICES Working Group on the Assessment of Demersal Stocks in the North Sea and Skagerrak (WGNSSK) to illustrate the possible consequences of improving the selectivity of haddock in the North Sea. This model predicts future biomass, catches and discards for a given stock based on estimates of fishing effort and fishing mortality and a given stock recruitment relationship.

They consider the following three cases:

i) The Scottish whitefish fleet reduces the number of open meshes around the codend from 100 to 80 in 2005. All other conditions stay the same.

ii) The Scottish whitefish fleet reduces the number of open meshes around the codend from 100 to 80. In addition, the Scottish *Nephrops* fleet adopts a 95 mm mesh codend made of 5 mm double PE twine with 100 open

meshes around the circumference and a 120 mm square mesh panel (SMP) at a distance of 4–9 m from the codline.

iii) The same situation as case (ii) but the whitefish fleet are also permitted a 30% increase in effort

The long-term (11 years) effects on the yield (landings) and discards of each fleet and the spawning-stock biomass are compared with the situation had no changes been made.

The long-term stock predictions (using haddock selectivity estimates that are calculated from the empirical model presented above assuming a catch size of 600 kg) show that reducing the number of open meshes around the codend from 100 to 80 can have a considerable long-term effect on the spawning-stock biomass and the performance of the whitefish fleet.

In the first scenario, haddock discards from the whitefish fleet decrease by 68% but their landings only recover to initial the level after ten years. In contrast the haddock discards of the *Nephrops* fleet increase by 18% while their landings also increase by 54% in line with the 56% increase of the spawning stock.

In the second scenario, where the selectivity of the Scottish *Nephrops* fleet is also modified, both the Scottish whitefish and *Nephrops* fleets reduce haddock discards by about 70%. The spawning stock increases by 63% and the landings of the whitefish and *Nephrops* fleets increase by 6% and 34% respectively.

The third scenario examines the effect of introducing the above gear changes and also increasing the fishing effort of the whitefish fleet by 30%. This increases the landings of both the Scottish *Nephrops* and whitefish fleets by about 20%, reduces discards by 73% and 58% respectively and produces a 50% improvement of the spawning stock.

The analysis carried out demonstrates that both gear based technical measures will improve the spawning-stock biomass (SSB) of haddock. It is also likely that the SSB of a number of other commercial species, principally whiting and saithe and to a lesser degree cod will also increase. This effectively means that the first ecosystem category in the methodology i.e. “Commercial fish species” has been assessed for these particularly GBTM’s.

With respect to the other three ecosystem components no assessment was possible even when reviewing other studies testing similar gears. It was concluded that in theory it would be possible to collect data on “Listed species” (non-commercial fish species and benthic organisms) when carrying work of this type but whether this would be of sufficient resolution to assess whether the GBTMs would reduce impacts on such species to any degree is doubtful, given the lack of baseline data for many species. It was therefore felt impossible to assess such measures against the measures against the methodology but that researchers should be encouraged to collect information on such species in future and for the fish species try to build up selectivity data for them. To assess whether the measures where effective or not would then be dependent on gathering baseline data on unmodified gears.

Regarding the ecosystem components dealing with marine mammals, reptiles and seabirds, the logic of trying to assess this type of GBTM against this was questioned. Intuitively these gear modifications would have no positive or negative impacts on marine mammals, marine reptiles and seabirds, nor were they designed to do so. Similarly the impact on habitat assemblages also did not seem relevant to this particular GBTM.

17.6.2 Case Study Two – Protected Species Bycatch reduction devices

It has been identified by a number of sources including the EU, FAO and GFCM in the Mediterranean that in a number of fisheries mitigation measures to reduce bycatch of protected species (cetaceans, pinnipeds, turtles and large fish species) have been introduced and in many cases bycatch has been reduced. One such well documented measure is the use of acoustic deterrent devices. Active acoustic deterrents or 'pingers' are small self-contained battery operated devices that emit regular or randomized acoustic signals, at a range of frequencies, and typically loud enough to alert or deter animals from the immediate vicinity of fishing gear. Acoustic deterrents have been used in many gillnet fisheries and have been demonstrated to be effective at reducing harbour porpoise bycatch in these fisheries.

Few reliable assessments have been made to determine the exact efficacy of these devices in terms of bycatch reduction although in recent years, as reported by Palka *et al*. (2008), concerted efforts have been made to assess bycatch reductions for the US Northeast gillnet fishery. In the context of the methodology it is felt worthwhile to describe this assessment as it illustrates how potentially a GBTM can be assessed to meet the primary objective of reducing bycatch of protected species.

Harbour porpoise bycatch in the US Northeast gillnet fishery is managed under the Harbour Porpoise Take Reduction Plan (HPTRP), which was implemented on 1 January 1999. The HPTRP divides this fishery into management areas that are either completely closed to all gillnets or closed only to gillnets that do not use pingers. A recent analysis of 25 000 observed gillnet hauls reported by Palka *et al*. (2008) found that whereas in a 1994 controlled scientific experiment conducted in part of this fishery that used 15 cm mesh gillnets, the bycatch rate in pingered nets was 92% less than that in nets without pingers. In contrast, in the operational fishery, the bycatch reduction in pingered nets was only 50–70%, depending on the time, area and mesh size. The analysis found that the apparent decrease in pinger effectiveness in the operational fishery was partially due to the type of gillnet used and also a lack of compliance. Pinger usage started out high in 1999 (the first year required), dropped substantially during 2003–2005 and perhaps due to outreach activities increased beginning in 2006. During years of high pinger usage, 87% of the tested pingers were functional, while only 36% of the tested pingers were functional during years of low pinger usage. In general, as expected, observed bycatch rates in hauls without pingers were greater than bycatch rates in hauls with the required number of pingers. In conclusion, based on a weighted average bycatch rate calculation described by Palka *et al*. (2010), pingers appear to have helped reduce the bycatch rate. According to this analysis porpoise bycatch has been reduced below the Potential Biological Removal Rate set for this fishery. However, due to pingers being only part of a wider set of measures including closed areas so therefore it is not possible to separate the reduction in bycatch due to pinger use and bycatch reduction due to other measures.

Taking the four ecosystem components defined in the methodology it is obvious that this particularly GBTM has the main objective of reducing the bycatch of marine mammals. The assessment reported is felt to be the only comprehensive assessment of this type of GBTM carried out. It clearly shows the efficacy of the gear measure but also highlights the difficulties in assessing its actual benefits due to confounding factors.

Regarding the other three ecosystem components, only the "Commercial Fish Species" could be anyway assessed. Nearly all studies of acoustic deterrent devices or other mitigation measures designed to reduce bycatch of protected species record

catches of commercial fish species routinely. This is mainly to demonstrate to fishers that the GBTM has no impact on catch rates. In addition for this particularly measure a number of researchers (Mann *et al.*, 1998; Mann *et al.*, 2001; Popper, 2001) have shown acoustic deterrents to create only minimal reactions with a very few commercially exploited species.

The ecosystem components dealing with Habitats and assemblages were deemed to be of no relevance to GBTM of this type as intuitively they would have no impact.

17.6.3 Case Study Three – Benthic Impact

Scientists from the Alaska Fisheries Science Center (NOAA Fisheries) have been working with the bottom-trawl fleet of the Bering Sea to modify their trawl gear to reduce damage to habitat and unobserved crab mortality. These trawlers use very long cables (sweeps) between trawl doors and net to herd and capture flatfish from a much wider area than is swept by the net itself. Because sweeps cover most (up to 90%) of the fished area and because the fishery operates exclusively on unconsolidated sand/mud substrata, modifications to raise sweeps 5 – 10 cm above the seabed were selected for testing. This was accomplished with widely spaced (10 – 20 m) disk cluster or bobbins that were found to greatly reduce direct contact with the seabed, while providing a small space for benthos to pass through. Twin trawl comparisons confirmed that raising sweeps less than 7.5 cm had no significant effect on flatfish herding, with spacing of 10 cm resulting in minor reductions (Rose *et al*., 2010).

To examine how modifications affected damage to seabed animals, the researchers created a series of parallel trawl tracks using a range of modified and conventional sweeps. One to two days later, a seabed sled with both sonar and video sensors was towed across all of the parallel trawl tracks at several points to compare the condition of seabed animals in areas affected by these different gears, as well as control areas between tracks. At a site inhabited by sea whips, tracks were resampled after approximately one week, one month and one year. These studies indicated a reduction in damage to sea whips that persisted over time.

Tests were conducted on three other animals to examine the effects of modified sweeps. While these did not produce statistically significant results, all had effects in the direction of less damage with the modified sweeps. In addition, two similar experiments were conducted at two sites where the structural fauna were dominated by ascidians. Analyses of those data were thwarted by an inability to consistently classify those animals into damage categories. In comparison with the conditions of animals in the control areas, it was just not clear how or whether those invertebrates had been affected by either sweep configuration.

The effects of sweep modifications on crab mortality rates were explored by recapturing crab after encounters with trawl sweeps and comparing the proportion dying to crabs captured in a similar manner with no sweep encounter. Tanner and snow crabs (*Chionoecetes bairdi* and *Opilio*) had 4% and 6% mortality with conventional sweeps (adjusted for handling mortality), while mortality rates with the modified sweeps were not significant different from crabs captured with no sweep encounters. Estimated mortality rates were also reduced for red king crabs (9% conventional – 4% modified).

Requiring these modifications during all trawling for Bering Sea flatfish has been recommended for implementation beginning January 2011 by the North Pacific Fisheries Management Council and those regulations are in process. Manuscripts of the benthos and crab results are in process.

Taking this study in relation to the methodology, it seems that it is much more relevant to this type of study. Of the four ecosystem components, all but one of them seems directly relevant to the objectives of this work. An assessment has been carried out for "Commercial Fish Species", "Listed Species" and also "Habitats and Assemblages". Whether the data collected is of sufficient resolution is though open to question but the fact that this work ahs directly led to the gears being adopted into legislation suggest the assessment carried out is suitably robust.

17.7 Conclusions and Recommendations

1) On the basis of the three case studies considered, WGFTFB conclude that the methodology developed is unduly complex and data demanding to be applicable for assessing GBTMs. In addition it is further concluded that the use of Significant Adverse Impact is not an appropriate metric as in reality data deficiencies make it extremely difficult to show any GBTM, even extensively studied ones would reduce SAI to any degree.

2) Despite these major limitations, WGFTFB concludes that the methodology could be adapted to assess GBTM's developed to reduce benthic impacts. Such gear measures impact on a number of ecosystem components and in such studies, researchers routinely collect information on a wide range of species as well as looking at habitat impact.

3) WGFTFB recommend that gear technologists carrying out research with gear measures designed to reduce bycatch and/or discarding should be encouraged to collect information on as many species (both commercial and non-commercial) as possible to allow more information and ultimate analysis of whether such GBTM can deliver positive benefits for the stocks of these species. This should be in line with guidelines being developed by WGISUR.

4) WGFTFB conclude that the protocol used in the UK study (Catchpole *et al.*, 2008) to evaluate the legislation put into force for the *C. crangon* fisheries is both holistic and effective. The same protocol can potentially be used elsewhere in other fisheries to conduct similar evaluations on the efficacy of technical measures. This protocol includes an evaluation of the legislation text, performance of the gear modifications, including environmental effects and a socio-economic evaluation.

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18 Summary of other presentations

18.1 Oral presentations

18.1.1 Selection of *Nephrops* based on the FISHSELECT methodology

Rikki Frandsen, National Institute of Aquatic Resources, Hirtshals, Denmark

Abstract

A simulation-based attempt to quantify the morphological component of size selection of *Nephrops norvegicus* in trawl codends. The selectivity for *Nephrops* (*Nephrops norvegicus*) in trawl codends generally is poor and the lack of steepness of the selec-

tion curve results in high discard rates and/or loss of legal-sized catch. This poor codend selectivity often is attributed to the irregular shape of *Nephrops*, which to some extent characterizes the problem as insoluble. In the present study, the FISHSELECT methodology was used to examine the selection process of the species in order to identify ways to improve selectivity. The use of three different modes of orientation for contact (contact modes) with the codend meshes explained most of the characteristics of the selection curves for *Nephrops* obtained experimentally. The contact mode with the smallest cross section was optimal for mesh penetration and, when evaluated against experimental data, 87.5% of all *Nephrops* encountering the gear were estimated to meet the netting in this contact mode. The range of configurations of the meshes (e.g. opening angles in the diamond mesh netting) was determinative for the selectivity, and the selective process for *Nephrops* was found to take place along the entire length of the codend. Simulating selectivity in a diamond mesh codend in which the closed meshes in the forward part of the codend were replaced by more open meshes revealed that the selectivity for *Nephrops* can be efficiently improved.

Discussion

It was suggested that the selectivity data compiled for the ICES WKNEPHSEL workshop held in 2007 could be used to further test the model, particularly from Portuguese data collected from covered codend experiments with measurements across a wide size range could be used. Other historic data compiled by WGFTFB in 19—may also be useful.

The question was raised as to whether multiple escape attempts (3–5 times) by *Nephrops*, which have been observed by work carried out by Main and Sangster and others, could be simulated in the model. The authors felt that this was possible but to date they had based it on a single escape attempt. It was also pointed out that poor visibility, which is common in *Nephrops* fisheries due to mud means that escape is likely to be mechanical rather than visual.

A question was raised regarding the mechanics that caused the distortion of the individual meshes in the square mesh codend. It was explained this was due to the ----.It was also stated that knotted double twine distorts more.

18.1.2 Sea trials for 8 trawl selectivity devices in the mixed hake-*Nephrops* fishery of the Bay of Biscay

Marc Meillat, Sonia Méhault, Jean Philippe Vacherot, Fabien Morandeau, Mathieu Mouchel, Ifremer, France

Abstract

The mesh size used in mixed Hake-*Nephrops* fishery of the Bay of Biscay is of 70 or 80mm gauge, whereas it is of 100mm gauge if fish only is targeted. This leads to a poor selectivity of juvenile fish, and technical solutions have been investigated to reduce the catch of fish below minimum landing size (MLS) without losing too many *Nephrops* above MLS.

Therefore, 8 different selective gear designs have been compared successively to a standard commercial trawl on board of the RV "Gwen Drez" during spring 2009 according to the twin trawl method: 2 square mesh cylinders (62 and 70mm), a combination of grid and square mesh panels, 2 settings of Radial Escape Sections (RES), and 3 rig designs to force the mesh opening (2 settings of 75% hanging ratio and T90). All devices have been observed with underwater video systems.

The catch comparison analysis for the square mesh cylinder showed a good escape rate for juvenile hake with a relatively low loss of *Nephrops*, either below or above MLS. The grid and square mesh panels combination was efficient at releasing both, juvenile of *Nephrops* and hake with low escapement of commercial individuals. The escapement rate with the RES was highly dependent and sensitive on its setting. The opening mesh designs appeared to be non-adapted to the mixed fishery with a very high escape of commercial *Nephrops*.

The coming perspective of this work is the transfer of the best performing devices to the fishing industry on a voluntary basis.

Discussion

The question was raised regarding the twine diameter and twine thickness used in the T90 experiments and whether this could be reduced to reduce the losses of marketable *Nephrops* observed. The authors explained that the codend used was designed to match the current regulations regarding mesh size and twine thickness and hence 70mm x double 4mm twine was used.

A further query was raised on whether the hake was an important bycatch or was the fishery essentially a single species fishery for *Nephrops.* It was stated that it depended primarily on the market price for hake but usually it was considered an important catch component.

18.1.3 The use of Social Marketing to reduce Discarding

Andy Revill, Cefas, UK

Abstract

The use of 'Social Marketing' in fisheries to reduce discarding. In the UK, we have been using 'Social Marketing' as a technique (on a pilot basis) to encourage fishers to reduce discards. To date, in our pilot studies, we have had some good success with discard reductions exceeding 50% overall. We note that 'Social Marketing' can help to identify the right incentive framework needed to facilitate a desirable behavioural

change (i.e. in this case - reduce discards) where other approaches may fail (such as legislative, expert led, economic incentives, demonstration approaches).

Discussion

The question was raised if the fishers had participated in the project voluntarily or had been approached directly as this would have a bearing on their attitude. It was explained the fishers were selected on the basis of questionnaires and interviews and the ones selected had all indicated that they recognized that discarding was a problem in this particular fishery.

It was asked whether there been uptake by any other fishers other than 10 involved in the project and what percentage of the fishery was represented by three 10 vessels involved. It was replied that no other boats were involved and the 10 boats represented around 505 of the fleet operating in the fishery.

It was asked whether all the vessels had used the same approach and modified net designs. The author replied that all of the boats had used slightly different designs and in fact one boat had used a design that had been tested by Cefas previously.

A question was raised as to whether participation in the project had led to increase fish prices for the boats involved but no data had been collected on this although there was an indication that they had received some small increases.

18.1.4 Discarding in *Nephrops* trawl fisheries in Iceland

Haraldur Einarsson, Olafur Ingolfsson, Institute of Marine Research, Iceland

Abstract

Nephrops norvegicus trawl fisheries have a high discard rate, partly explainable by the small-meshed nettings that *Nephrops* trawls consist of. The upper trawl panel does not serve the purpose of retaining *Nephrops* which pass along the lower panel. The reason the upper panels of *Nephrops* trawls have smaller meshes than whitefish trawls are unclear. In an attempt to reduce catches of juvenile fish in the Icelandic *Nephrops* fisheries, the mesh sizes in the upper part of a commercial *Nephrops* trawl were increased and the netting hung to force wide mesh opening. Three different designs with 135 mm nominal mesh upper panel from the square and backwards, were compared to an unmodified commercial trawl with 80 mm meshes and two 200 mm square mesh windows. The comparison was conducted by towing both trawls simultaneously in three trips in June 2009 in the southeast of Iceland. Design A had a 23.2 m long panel about one third narrower and longer than the corresponding 17.3 m lower panel, extending to 9.7 m from the cod-line. Design B had a 16.1 m long panel, one third narrower and longer than the matching 12 m lower panel, extending to 15 m from the cod-line. Design C had a 14.1 m long panel, one third narrower and 17% longer than the matching 12 m lower panel. With design A, about half of *Nephrops*, haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) catches were lost while with design B, the losses were restricted to smaller specimen of fish and *Nephrops*, i.e. a marked size selection was observed. In design C no size selection of *Nephrops* and haddock could be detected. These trials demonstrate the potential for size selection of *Nephrops* and gadoid fish by a simple manipulation of the upper panel of a *Nephrops* trawl to reduce discarding.

Discussion

It was asked whether increased meshing was observed in the modified design, particularly in the areas of slack netting indicated. This had not been a particular problem in these trials but it was felt that may well be a significant problem if capelin were present in the area.

18.1.5 Scottish cod trials

Barry O'Neill and Rob Kynoch, Marine Scotland, UK

Abstract

Large diamond mesh netting in the forward sections of trawls to reduce catches of cod. The results of a number of experimental trials on gears which have incorporated large diamond mesh netting into the forward sections of the trawl are presented. The experiments are of two types, namely, those where discrete large diamond mesh panels have been fitted and those where the mesh size of the whole of the forward section has been increased. The mesh sizes examined are 300, 600 and 800mm. The results demonstrate that, for cod, selection is related to mesh size and that increasing the mesh size of all of the forward section is more effective than inserting discrete panels. The effect of these modifications on other commercially important species such as haddock, whiting, monkfish and megrim are also discussed.

Discussion

The question was raised as to whether the losses of marketable fish demonstrated in the trials with the 600mm net modification was acceptable to the fishers. It was replied that it depended on the fishery. For boats targeting mixed species including megrim and monkfish, the losses were too high but for boats targeting haddock, whiting and cod it was much more acceptable.

It was remarked that in many cases when you develop a gear like this with reduced drag that fishers tend to simply increase the size of gear over time, thus negating any benefits in lower fuel consumption. It was replied that in this case this had not been observed as the boats in the fishery tended to keep gear size small relative to the vessel horsepower so that the gear could still be towed efficiently during periods of bad weather in winter. Fuel prices were also an increasing driver for keeping ear size small.

18.1.6 Irish Experiences with Sorting Grids in *Nephrops* Fisheries

Dominic Rihan, Bord Iascaigh Mhara, Ireland

Abstract

The EU Fisheries Councils in November and December 2008 adopted a new Cod Recovery Plan, which restricts fishing effort in certain areas and with certain gear types. Under this regulation, Member States can apply for groups of vessels to be exempt from days at sea provided they can demonstrate they consistently catch less than 1.5% cod by trip. In 2009 BIM began testing a variety of gear options that would allow *Nephrops* fishers to continue to fish with reduced cod catches meeting the 1.5% threshold. The trials were carried out in March/April 2009 with several different gear modifications tested but the overall conclusion from these trials was that a rigid sorting grid was the most efficient gear and gave consistent reductions in cod catches. Following on from the technical trials three vessels opted to use the rigid sorting grid

in Area VIIa and were allocated additional effort on the basis that they fished solely with the modified gear. The three vessels initially tested the grid on a voluntary basis during several trips between July and October 2009 to assess the practicalities of using the grids. These engineering trials were conducted under full commercial conditions and carried scientific staff from BIM/MI to evaluate the impact of grids on catches. Following on from the engineering an enhanced observer programme of these three vessels has been carried out by BIM/ MI and the data collected has confirmed that cod catches are consistently low and well below the 1.5% threshold. Cod catches aggregated across all observed trips were 0.06%. All of this work has formed the basis for a case for exemption for these three vessels, which has been submitted by DAFF to the EU.

This paper discusses the progression from the experimental phase to the voluntary adoption of the grid by fishers in return of additional effort and ultimately exemption from the days at sea regime. It demonstrates a high degree of cooperation between industry and science in developing a technical gear solution to a specific fishery problem and also that fishers will make changes to their operational practices if real incentives to do so exist.

Discussion

The question was raised as to whether the exemption the vessels had received was a total exemption. It was replied this was the case and had been a big driver for the vessels involved given their operation.

It was remarked that it was strange that most people continue to test rectangular rather than oval or elliptic shaped grids. One partial explanation was given that the surface area with oval grids is reduced and can cause blockage problems. It was pointed out that in Canada oval grids are commonly used in the shrimp fisheries although these are constructed in plastic rather than steel.

The point was made that grids should be placed in 4 panel sections as this reduces mesh distortion in the trawl. People should be encouraged to routinely use 4 panel sections in future work with grids.

The question was raised whether plastic grids were an option. The author replied that they were and that he was looking at testing a Danish grid recently tested which was constructed in plastic, although it was difficult to have such grids constructed in Ireland due to a lack of specialist plastic manufacturers.

18.1.7 Fish Behaviour and Analytical Techniques determining of catchability coefficient for survey gillnets

Oleg Lapshin, VNIRO, Russia

Abstract

Fish Behaviour and Analytical Techniques Determining of catchability coefficient for survey gillnets (on the example of sturgeon in the Caspian Sea) the problem of survey gillnets catchability coefficient determination is considered. The most important factors that may lead to understanding the nature of the catchability coefficient for the gillnetting are well-known but the difficulties in determination the influence of them on determination of this coefficient are numerous. The factors influencing the value of catchability coefficient are type of gillnet, fish's species-specific features, type of biotope, time and season of fishing, and some others. Usually the catchability coeffi-

cient is assumed as a constant, though there are evidences of its dependence on fish abundance. In the presentation the results of 5-years research are shown. The model on determination of catchability coefficient is base on fish behaviour and distribution in the effective area of gillnets fishing from hydroacoustic and tagging. The most difficult tusk in this model is to evaluate effective area of gillnet for concrete species. The results of fishing and calculation all model's parameters are shown for Caspian sturgeons (Russian sturgeon and stellate sturgeon).

Discussion

The question was raised as to the reason for the differences in catchability between the two species of sturgeon observed in the experiments. The author replied this was probably due to differences in their morphology and feeding behaviour. The position they are caught in the net may also be significant.

It was asked whether the change in technique result in a change in the stock estimates. The author replied that it had resulted in a significant increase in stock size by about ten times the previous estimate.

18.1.8 Mortality rates of crabs passing trawl sweeps and footropes without capture and effectiveness of sweep modifications to reduce such mortalities.

Craig S. Rose, Carwyn Hammond, Alan Stoner, J. Eric Munk and John Gauvin, NOAA, US

Abstract

Unobserved mortality occurs when organisms die due to contact with fishing gear although they are not captured. We estimated unobserved mortality rates for three species of Bering Sea crabs after contact with various components of bottom trawls used in Bering Sea flatfish fisheries. Crabs were captured in small trawl nets towed behind the footrope and sweeps of a full-scale bottom trawl, assessed for injuries and reflex impairments and held in seawater tanks for 4 – 14 days to observe delayed mortalities. To account for mortalities due to capture and handling, crabs were also captured in one of the small nets fished on open seabed. Mortality rates for crabs caught in this control net were used to correct estimates of mortality due to the fishing gear for capture effects. Mortality rates were higher for red king crabs (*Paralithodes camtschaticus*) than for snow and Tanner crabs (*Chionoecetes opilio* and *bairdi*) and higher for crabs contacting the footrope than the sweeps. Modified sweeps, with disk clusters attached at wide intervals to raise them above the seabed, reduced crab mortalities substantially for all species.

Discussion

The question was raised as to whether the reflex methodology used in the experiments had been used for fish as well as crustaceans. The author replied that it had been originally developed for fish and had been used for assessing survival rates for halibut and black cod in particular. It was pointed out that this methodology should be used more extensively in future in survival work as it was much more cost-effective than expensive experiments with control populations that were subject to high mortality.

It was asked whether any size effects for the different species had been observed in the experiments. The author replied that no significant size or gender effects had been seen.

The question was asked as to whether the sweep modification had affected the catchability for fish species. It was replied that negligible losses of flatfish was observed but also a small increase in the catch of roundfish species. This may have been due to increased visibility from the reduced sand clouds generated by the modified sweeps.

18.1.9 The CatchMeter: video monitoring and real-time species and length analysis of fish in a trawl

Darren Hammersland-White[1], Jens Christian Holst[2], Shale Rosen[1], Cato Svellingen[1], John Willy Valdemarsen[2] and Jan Tore Øvredal[2]

[1]Scantrol AS, Bergen, Norway. [2]Institute of Marine Research, Bergen, Norway

Abstract

Scantrol AS and the Institute of Marine Research, Bergen, Norway are collaborating on development of an image capture system, the CatchMeter, capable of automatic species recognition, length measurement and sorting of fish in a trawl. The system has been used successfully in both demersal and pelagic trawls on research and commercial vessels ranging from 15 m to 94 m in length. Controlled illumination means the system can operate at any time of day and at depths ranging from the surface to 500 m.

Fish are guided through a frame located between the extension and codend of the trawl, where a camera takes multiple side-on, high quality, colour images per second. These images are stored and analysed in real-time to provide species and length data. Additional sensors (monochrome video cameras, mechanical flowmeters, depth, pitch and roll) log data simultaneously with the colour images. An Ethernet connection over a standard netsound cable allows both images and sensor data to be streamed to the vessel's bridge in real-time and provides control of all system functions. The system logs all data internally and can also operate in an autonomous mode without connection to the surface. Power is provided by a battery capable of running the system for up to 8 hours on a single charge and data storage capacity is limited only by the size of the hard drive used (currently > 50 hours).

All data are time-referenced and can be matched with the trawl's depth and geographic position, providing a continuous spatially-referenced record of fish distribution and auxiliary sensor data throughout the haul. So far the system has been trained to recognize four species of fish (Atlantic cod, Haddock, Atlantic herring, Saithe) with a classification accuracy of 97% for side-on oriented fish. More species will be trained as data becomes available. The current system is capable of measuring fish ranging from 20 – 60 cm in length, but accurate length measurement functionality is not yet fully implemented. Initial results show that the length measurements correlate well with manual measurements but implementation of stereo vision or other techniques will be required in order to increase accuracy. A sorting door located after the imaging area can be controlled in real-time by the user or the automatic species identification to either guide fish into the codend or release them again into the sea

Discussion

The question was raised as to the potential cost of the system as this was seen as a major factor in its use. The author replied that it was still a prototype system but indications were that it would cost somewhere in the region of $40,000, depending on

demand. It was pointed out that similar systems are already used in aquaculture to grade fish.

It was asked whether there were problems when fish density was high as the opening for the fish into the identification chamber seem relatively small. The author replied that this was a problem that had not been fully solved although modifications were being looked at. Currently if fish density is too high, particularly when pelagic species are present, then the escape door is kept open to allow fish to escape freely.

The idea was raised as to whether lights could be installed ahead of the system to encourage fish to enter the camera view field. This was felt a reasonable approach that was being considered. A further question was raised regarding whether poor visibility limited the effectiveness of the system. The author explained that so far they had obtained good results even when visibility was poor but accepted this was likely to be a limitation.

The question of transmission rates from the netsounder cable was raised. This was seen as a particular problem in pelagic fishing operations where the netsounder is used to routinely monitor the net. It was replied that the system uses the gaps between pulses in the netsounder to transmit data from the Catchmeter system. Simrad are actively working on addressing this issue. In connection with this point, it was asked why the PC in the unit is not kept on board rather than deployed in the unit. It was explained that this to increase processing speed.

18.2 Poster presentations

18.2.1 Hexagonal and turned mesh (t90) codends selectivity for bottom-trawl nets in the Aegean Sea

Adnan Tokaç, Celalettin Aydın, Uğur Erdoğan, Ege University, Turkey

Abstract

In this study, red mullet (*Mullus barbatus*), annular sea bream (*Diplodus annularis*), common pandora (*Pagellus erythrinus*), axillary sea bream (*Pagellus acerna*) and blotched picarels (*Spicera maena*) selectivity parameters were investigated with knotless 44 mm hexagonal mesh codend (HMC), 40 mm 90° rotated knotless polyamide codend (PA T90) and 44 mm 90° rotated knotless polyethylene codend (PE T90). Experiments were carried out by RV "EGESÜF"' between 05–12–2008 and 27–08–2009 with 900 meshes modified trawl net in around of Gülbahçe Bay and Hekim Island. A hooped covered codend technique was used for estimating selectivity parameters. Individual and pooled data selectivity parameters were determined with CC2000, mean selectivity parameters were calculated with EC Modeller programmer. 12 with HMC, 10 with PA T90, 3 with PE T90 valid trials were carried out. For red mullet L_{50} values were estimated 15.2 ± 0.0 cm, 14.2 ± 0.0 cm and 13.6 ± 0.2 cm in HMC, PA T90 and PE T90, respectively. For annular sea bream L_{50} values were determined as 10.6 ± 0.0 cm, 9.8 ± 0.0 cm and 9.5 ± 0.6 cm in HMC, PA T90 and PE T90, respectively. For common pandora L_{50} values were calculated 13.6 ± 0.2 cm, 13.0 ± 0.1 cm and 10.9 ± 0.6 cm in HMC, PA T90 and PE T90, respectively. For auxiliary sea bream L_{50} values were estimated at 14.3 ± 0.3 cm, 14.0 ± 0.1 cm and 13.3 ± 0.2 cm in AGT. PA T90 and PE T90, respectively. For blotched picarel L_{50} values are determined as 17.0 ± 0.6 cm, 16.4 ± 0.6 cm and 14.3 ± 0.1 cm in HMC, PA T90 and PE T90, respectively. As a result, a lot of fish which have different morphological characters can be caught in Eastern Mediterranean demersal trawl fishery. A mesh size and type appropriate for one species will

be unsuitable for many others. Therefore, in addition to size selectivity, species selectivity and fish behaviour studies need to be investigated.

19 National Reports

The contents of the individual National reports are NOT discussed fully by the group, and as such they **do not necessarily reflect the views of the WGFTFB**.

19.1 Canada

Fisheries and Marine Institute of Memorial University of Newfoundland

Energy Efficient Shrimp Trawl

Collaborative research began in 2009 to investigate methods of reducing fuel consumption during inshore shrimp trawling activities in Newfoundland and Labrador, Canada. Working with local trawl manufacturers, various technical measures were examined during two separate studies in an effort to reduce hydrodynamic resistance of the common trawl designs in use by the fishing industry. Two studies tested the feasibility of shortened bridles, reduced twine diameters, modified footgear, increased mesh size, and improved trawl door design, all as means for reducing hydrodynamic drag and saving fuel. The work was conducted under the controlled conditions of a flume tank in St John's, Newfoundland, Canada, using scaled engineering models (1:4, 1:8, and 1:40). The results were highly encouraging, but require full-scale at-sea comparative fishing experiments in order to be further validated.

Contact: George Legge (George.Legge@mi.mun.ca) or Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Underwater Observations - Flatfish Trawl Capture

Sea trials are currently being conducted to investigate flatfish behaviour in the mouth of commercial bottom trawls targeting yellowtail flounder on the Grand Bank. The university's self-contained underwater camera was upgraded to high definition (full HD, 1080p) with solid-state recording on DVR. Several trips have been conducted with more expected. The objective is to determine factors affecting capture efficiency and size-specific behaviour patterns.

Contact: Paul Winger (Paul.Winger@mi.mun.ca).

Biodegradable Twine

Thousands of snow crab traps are estimated to be lost each year around Newfoundland and Labrador. The traps are made of PE netting and do not contain any device to disable the trap if it is lost or abandoned, resulting in ghost fishing. An experiment was conducted to evaluate various natural fibres/twines (cotton, hemp, jute, and sisal) for their breaking strength over time under cold Newfoundland conditions. A total of five twines were evaluated in field trials, covering a period of 124 days. The 96-thread cotton twine performed the best. Compared to the other twines evaluated, the rate of degradation for this twine was relatively quick, with a 33% reduction in the initial breaking strength recorded after 64 days, and a total reduction of 63% of the initial strength upon conclusion of the study at 124 days. Fishing enterprises (n=60) were requested to sew the biodegradable twine into their traps for the 2010 fishing season.

Contact: George Legge (George.Legge@mi.mun.ca).

Cod Potting

Potting for Atlantic cod continues to gain momentum in Newfoundland as an alternative harvesting strategy to gillnets. The gear type is now legalized by the federal government. The upcoming 2010 cod fishery will include 10 fishing enterprises catching their entire commercial quota using baited cod pots. A value chain has been assembled straight through to restaurants where consumers pay more sustainably caught fish.

Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).

Escape Mechanisms in Snow Crab Traps

Escape mechanisms have been introduced into the commercial snow crab fishery on an experimental basis each year since 2005. Currently, 132 fishing enterprises in 58 communities are evaluating their commercial viability. Catch data continues to show that installing mechanisms around the bottom of the trap results in reduced numbers of under-sized crab being caught and discarded. A promotional / educational video has been prepared and distributed on DVD and on the web.

Contact: Paul Winger (Georgina.Bishop@mi.mun.ca).

Fisheries and Oceans Canada Central and Arctic Region

Modifications to the Campelen shrimp Trawl

The standard Campelen 1800 shrimp trawl excessively tear-up in northern assessment surveys in the Hudson Strait area. Modifications were made to the trawl which increased the foot gear from the standard 14 inch roller to 21 inch diameter. In addition floatation was added to the fishing line in order to further lift the bellies of the trawl away from the bottom. A model of the modifications was tested in the Flume Tank at the Marine Institute, St John's, NL to fine tune the amount of floatation added to the fishing line and to examine the effects these modifications might have on the performance of the trawl.

Contact: Tim Siferd (Tim.Siferd@dfo-mpo.gc.ca).

Modelling the Cosmos Shrimp Trawl

A Cosmos 2600 shrimp trawl is the standard trawl used by DFO_C&A shrimp assessment surveys conducted in the north. In order to develop a mathematical model relating door spread to swept width by the trawl, a model of the Cosmos trawl was built and tested at the Marine Institute's Flume Tank in St John's, NL. Results showed that the determination of swept width required a multiple regression using both door spread and trawl speed.

Contact: Tim Siferd (Tim.Siferd@dfo-mpo.gc.ca).

Fisheries and Oceans Canada Newfoundland Region

Sinking Rope:

This ongoing experiment aims to determine if the use of a sinking rope reduces entanglements of marine mammals and leatherbacks turtles in Snow Crab and Whelk fisheries by eliminating the natural snare created between traps. The sink rope was distributed to 5 Snow Crab and Whelk fishers in 3PS area to assess the practicality of using *Hydropro* rope during the 2009 Snow Crab and Whelk fisheries. At the end of

the season, entanglement statistics were compared to 5 fishers using traditional rope. One leatherback turtle was entangled in the traditional polypropylene rope (the leatherback turtle was disentangled and released unharmed). It was determined that the rope preformed as well in the commercial fixed fishing gear, maintaining the fishing effectiveness and handling characteristics of traditional rope. The information collected will be used by fixed gear fishers and fishery managers to improve management plans to mitigate marine mammal and leatherback turtle entanglements.

Contact: Erin Dunne (Erin.Dunne@dfo-mpo.gc.ca).

Bottom Seining Review:

Efforts are currently underway in collaboration with the Fisheries and Marine Institute to review the current and historical development of Canadian bottom seining technology with special emphasis on developments in the east coast fisheries.

Contact: Steve Walsh (Steve.Walsh@dfo-mpo.gc.ca).

Merinov Centre d'Innovation de l'Aquaculture et des Pêches du Québec

Reducing trawl drag to reduce fuel consumption in shrimp fishery

Earlier results using different trawls with different drag measurements revealed a strong relationship with fuel consumption. The results lead to the design and numerical simulation of a new trawl with reduced drag compared to the standard trawl. Commercial sea trials were conducted in June 2010 in Québec. The results were highly encouraging, but further statistical analysis is required.

Contact: Laurent Seychelles (lseychelles@cgaspesie.qc.ca).

Mitigating the bottom impact of scallop dredges

The objective of this study is to examine new options to mitigate bottom impact of scallop dredging in Québec. The first step of this project is to conduct an inventory of fishing gears used in Québec by the scallop industry. At the same time, a literature review will allow us to identify R&D solutions to reduce physical impacts of scallop dredging. Results of these studies will be presented and debated during a workshop planned during autumn 2010.

Contact: Antoine Rivierre (arivierre@cgaspesie.qc.ca).

Energy efficiency of fishing boat stabilization

The performance of different fishing boat stabilization technologies will be tested in the snow crab fishing industry. Commercial sea trials are expected this summer in Québec.

Contact: Marie-Hélène Fournier (mhfournier@cgaspesie.qc.ca).

19.2 France

Institute: Ifremer

Contact: Pascal Larnaud (Pascal.Larnaud@ifremer.fr)

Energy savings and lower impact on the seabed

OPTIPÊCHE project

OPTIPECHE national project ("Pôle Mer Bretagne") aims to improve trawl gear design in order to reduce fuel costs and impacts on the seabed. Work planed in 2009 was dedicated to testing T90 trawl designs, including flume tank testing and sea trials. Physical measurements and video observation permitted comparison with standard T0 optimized reference trawl. These tests showed that the large opening of T90 meshes in the whole trawl and in the codend, even without catch, can be achieved. The size of the meshes has to be adjusted, though to the targeted species. Another part of OPTIPECHE project permitted the deployment of so called "Jumper" trawl doors (innovative low impact doors) on a commercial trawler to assess ergonomics and safety aspects. Easy handling and a favourable response from crew members were observed on board.

HYDROPECHE project

HYDROPECHE national project aims to improve knowledge in the field of hydrodynamics of fishing gear. The project is split into three parts. The first focuses on numerical simulation of the flow around netting constructions using efficient recently developed methods. Another part is dedicated to flume tank experimental studies in order to validate results provided by simulation studies. The final part aims to develop an automatic optimization process for trawls in order to reduce fuel consumption, based on geometry modifications.

After the first year, the Hydropêche project has provided interesting results for the 3 parts of the study. The better understanding of flow enables identification of the areas generating drag, data which will be useful to validate the numerical simulations. The optimization software developed makes it possible to improve significantly the energy efficiency of pelagic and bottom trawls. Experiments are carried out on commercial vessels in the English Channel to validate the results of the numerical simulation. As part of this project preliminary results were presented at E-Fishing Conference in Vigo in May 2010:

- Experimental analysis of the characteristics of the flow around bottom trawls, E. Bouhoubeiny, G. Germain, P. Druault, E-Fishing 2010, Vigo
- HydroPêche: a way to improve energy efficiency of fishing devices, G. Germain, P. Druault, R. Lewandowski, B. Vincent, D. Priour, J. Y. Billard, E-Fishing 2010, Vigo
- Numerical method for energy optimization of bottom trawl, R. Khaled, D. Priour, E-Fishing 2010, Vigo

Alternative fishing gears

ITIS SQUAL project: Fish pots and *Nephrops* traps

The ITIS project being conducted by Ifremer, Lorient aims to develop new fish pots, *Nephrops* creels and new devices to reduce mechanical constraints on the trawl

catches. Together with a local netmaker, 5 prototypes of fish pots were designed and tested in a flume tank. Trials at sea were then conducted during spring 2009 in order to assess the ergonomics and efficiency of the newly designed gears. The performance of the 5 models were assessed and compared. The results were presented to the industry and discussed in order to initiate a wider use of these passive gears.

Newly designed *Nephrops* creels, together with common designs used in other creel fisheries (e.g. Scotland), were tested on board various artisanal commercial vessels. The yield and performance of the gears were assessed. The ITIS project ended up early 2010 with new models of fish pots now available on the market. This project was carried out in synergy with ORCASAV project (see below) to test prototypes and collect field observations.

ORCASAV project

This project which involves several fishing companies, a fishing gear manufacturer, and institutional organizations aims to develop fish pots to mitigate against depredation (40%) caused by killer whales to toothfish and also seabird mortality, in the area of Kerguelen and Crozet Islands. In 2009 a bibliography review was completed. Pots were then designed supplied and tested in a flume tank. Measuring and monitoring equipment development of measuring equipment including video systems were then tested at sea on board a commercial vessel in January/February 2010 (45 days).

Selectivity

SELECTMER project

This project, aims to reduce whiting discards significantly in the demersal fisheries of trawlers registered in Boulogne sur Mer and Etaples and operating south of the North Sea and in the eastern area of the Channel. This project began in 2009. It was carried out in partnership with the Regional Fisheries Committee of Nord Pas de Calais-Picardie. This study showed the benefit of using a flexible grid with 23mm bar spacing with an escapement rate of 30% of the small whiting below 22cm and 50% of plaice below 27cm. Nevertheless, these results have to be improved to be commercially acceptable. The trials will continue in 2010 under a new project, SELECCAB. This project aims to improve selectivity, both for whiting and cod. The gears to be tested include large mesh trawls and selective grids have been modelled in 2009 (numerical simulation, flume tank trials, protocol).

Selectivity trials in the mixed fishery *Nephrops*/Hake in the Bay of Biscay

Several trials at sea have been completed in 2009 on the Ifremer Research trawler "Gwen-Drez". These trials aim to determine the best selective devices to be tested at sea on commercial vessels in 2010/2011 under the "Selectivity for Sustainable Fisheries" project, in partnership with AGLIA (*Association du Grand Littoral Atlantique*). A square mesh cylinder and a new design of the flexible *Nephrops* grid have been preliminarily tested with positive results for hake and *Nephrops.* The objective is now to combine these two devices to reduce hake and *Nephrops* discards by 50%. This combination will be tested in 2010.

PRESPO project (INTERREG)

Two main research axes have been developed under the INTERREG PRESPO project during 2009: (1) the assessment and the improvement of the survival rate of dis-

carded *Nephrops* from the bottom-trawl fishery of the Bay of Biscay and (2) the study of the T90 codend design (which was combined with the ITIS SQUAL project).

To assess the survival rate of discarded *Nephrops*, tow trials at sea have been conducted on board both commercial and research vessels. This study was conducted in close collaboration with industry and scientists. Only partial results have been obtained so far (more trials are required by the agreed sampling scheme), and the experiment will continue in 2010. At the same time, the possibility of improving the survival rate through modifications to the fishing deck is being investigated.

The T90 codend design (70mm mesh size) was tested in flume tank at small scale, then tested at sea on board the RV "Gwen Drez". This design aims to force the mesh to open and increase the codend selectivity. This design was tested in the hake/*Nephrops* mixed fishery of the Bay of Biscay, but the trials resulted in a consequent loss of commercial *Nephrops*, which was not acceptable to industry. T90 seems more adapted to directed fish fisheries, unless mesh size is decreased below the current legal minimum mesh size of 70mm (for diamond meshes). Other selective bottom-trawl designs, more appropriate to this mixed fishery, are currently under investigation.

Safety at Sea

SOS stabilité Project: Safety at sea

SOS Stability project began 15 months ago. The project focuses on dynamic stability of small boats (12m to 24m). The objective of this national funded project is to improve the design of small trawlers, of fishing gear interface and eventually of fishing gear themselves in order to increase safety on board. Ifremer participation for year one consisted in developing a software interface between trawl gear dynamic simulation and hull dynamic simulation for the SIREHNA partner.

19.3 Iceland

Marine Research Institute, Iceland

Contact: Haraldur Arnar Einarsson (haraldur@hafro.is); Ólafur Arnar Ingólfsson (olafur@hafro.is); Einar Hreinsson (eihreins@hafro.is).

Bycatch reduction in *Nephrops* trawling

In an attempt to reduce catches of juvenile fish in the Icelandic *Nephrops norvegicus* fisheries, the mesh sizes in the upper part of a commercial *Nephrops* trawl were increased and the netting hung to force mesh opening to widen. Three different designs with 135 mm nominal mesh upper panel were compared to a standard commercial trawl in June 2009. Design A had a 23.2 m long panel, one third narrower and longer than the corresponding lower panel, extending to 9.7 m from the cod-line. Design B had a 16.1 m long panel, one third narrower and longer than the matching lower panel, extending to 15 m from the cod-line. Design C had a 14.1 m long panel, one third narrower and 17% longer than the matching 12 m lower panel. With design A, about half of *Nephrops*, haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) catches were lost while with design B, the losses were restricted to smaller specimen of fish and *Nephrops*, i.e. a marked size selection was observed. In design C no size selection of *Nephrops* and haddock was detected. Catch comparison trials will continue in 2010.

The effect of hook and bait sizes on size selection in longline fisheries

The effects of hook and bait sizes on fishing efficiency and size composition of cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), wolffish (*Anarhichas lupus*), ling (*Molva molva*) and tusk (*Brosme brosme*) were investigated in a designed experiment in the Icelandic longline fishery. Five hook sizes, EZ 10–14, and two bait sizes, ~10 and 30g, were compared. The bait was Saury (*Cololabis saira*). In general, bait sizes affect catch rates and size selection in longline fishery, while smaller hooks result in higher catches. The proportion of catch of juvenile fish appeared to be inversely related to fish abundance.

Escape of fish below a demersal trawl

Collecting bags were attached to the fishing line of a commercial trawl with a rock-hopper gear to collect fish passing underneath the fishing line. The trawl was constructed of small mesh netting to collect all fish entering the trawl opening. Fish from the collecting bags and main codend were measured and counted to account for size dependent escape of fish below the gear. Significant differences were found between the species recorded. More than 10 species were recorded.

Attraction and trapping of cod

The objective of this project is to investigate cost-effective ways to trap cod. This work is based on direct observation of how cod are caught in traditional traps/pots and is divided in three phases: 1) Finding useable odour-solution to use for attraction. 2) Building of odour releaser and control unit. 3) Testing of equipment and effects of odour release. The first phase was finished in 2008, no mixtures of amino acids were found efficient unless in extreme quantities but a solution with mixed herring, and even boiled herring mix was found to be effective in attracting cod. Building of odour releaser, control unit and camera rigging with the ability of remotely control and observe the devices through wireless communication interface, was completed in autumn 2009. The first commercial tests were carried out in October and November 2009 without any traps. Herring mixture was released in short pulses and reaction and behaviour of fish observed. In May 2010 the monitoring gear was deployed again with a circular trap, 1.4 m in height and 3.2 m in diameter. Tests are now underway and results are encouraging.

Electronic logbook

It has been mandatory to complete a fishing logbook in Iceland for many years, with positions, types of fishing gears, estimated catches etc. The fleet is now adopting electronic logbooks with increased information on types of fishing gears and devices, improved accuracy in position and continuous registration via mobile phones and satellite systems. This program has been ongoing for some years, and considerable effort has been allocated to the project to define registration variables and programming.

19.4 Ireland

Bord Iascaigh Mhara, Ireland

Contact: Dominic Rihan (Rihan@bim.ie)

Conservation and Selectivity Trials

In early February 2009 an Irish Ministerial Working Group was formed to look at the new effort and Technical conservation measures regulations introduced in 2009 by the EU as part of a Cod Recovery Plan for a number of areas. As a result of the deliberations of the Working Group, BIM was requested to carry out a series of trials to look at gear options that could reduce cod catches in the Irish Sea and West of Scotland and to assess the impacts of new mesh sizes introduced into the West of Scotland area. These trials began in March 2009 and to date 5 sets of trials have been completed with as follows:

- "Supreme II" (Clogherhead) – Celtic Sea/Irish Sea testing a rigid grid, inclined separator panel, and 160mm Square mesh panel for reduction of cod catches in prawn trawls.
- "Catherine-R" (Greencastle) – Analysis of the impact of new codend mesh sizes (120mm codend +120mm smp (12–15m from codend) for vesssels > 15m and 10mm codend +110mm smp (12–15m from the codend) for vessels < 15m required under new regulations in the West of Scotland Area and alternatives to these regulations. Only one option was tested 100mm +120mm codend (5–7m from the codend).
- "Green Isle" (Greencastle) – Continuation of trials above to assess alternatives which give low cod catches. The options tested against the baseline 120mm codend +120mm smp were 110mm codend +120mm smp (5–7m from the codend); 100mm codend with 160mm smp (5–7m codend); 100mm codend with 160mm smp (10–12m from the codend); and 80mm codend with 120mm smp (12–15m) against 100mm codend +120mm smp (5–7m from the codend)
- "Ocean Pioneer" (Union Hall) – Celtic Sea/Irish Sea testing a 200mm square mesh panel and a cutaway trawl with reduced top panel for reduction of cod catches in prawn fisheries.
- "Paul Stephen" (Greencastle) - Experiments to assess the effect of positioning of 120mm square mesh panels for cod, haddock and whiting selectivity in standard whitefish trawls. Square mesh panels at 6–9m, 9–12m and 12–15m from the codline were tested.
- Two further sets of trials with different combinations of codends and square mesh panels commenced in June on two < 15m vessels fishing in the Celtic Sea. These trials are designed to gather selectivity data for smaller vessels working on mixed fisheries. These trials are due to be completed by the end of July 2010.

During the period January – April 2010 engineering and observation trials with sorting grids have been ongoing with three vessels from the East coast of Skerries "Mater Dei", "Nausicca" and "Syracuse". These trials have been carried out in the Irish Sea and the data collected formed the basis for a successful submission to the EU for exemption from the days at sea regime currently in operation for use of the grid. In addition underwater footage of a range of grids was collected on a small inshore ves-

sel. This footage helped to resolve some technical issues related to the grids being used as well as highlighting a few other issues that need to be addressed. In connection with this BIM and the fishers involved attended two workshops hosted by the Scottish Government looking at gear options for reducing cod catches and also visited Sweden to compare their experiences with Swedish fishers.

Environmental Management Systems (EMS)

During 2009 and 2010, BIM continued to work closely with industry to further utilize the Seafood Environmental Management Systems (SEMS) developed in the last two years. By the mid-2010 close to 100 vessels had entered the programme. In addition to the successful outcome for the two pelagic mackerel fisheries achieving MSC and the vessels in the southwest achieving the West Cork regional code of practice, Fuchsia, the Erris Inshore Fishermen's Association has also undertaken a significant campaign to create a regional identity for the fish through the SEMS approach. The Industry also began the process of forming an SEMS Fishermen's Association for those vessels that employ the SEMS approach, while the SEMS's manual produced in 2008 has undergone its second iteration to incorporate the harmonization of a number of standards and codes of practice that are applicable to the Irish Catching Sector. This document has gained recognition by FAO and by others as a high quality document, easily adaptable to suit any fishery.

Waste Management

In 2007 BIM set up a dedicated baling centre was setup in Tramore. This site has continued to operate in 2008 and 2009 and to date a total of 89,000kg of nylon waste material has been collected from the industry with approximately 30% volume already having gone through the recycling process in recycling plants in the UK and China. This represents a sizeable reduction in the amount of waste fishing gear being sent to landfill sites. An economic appraisal of the operation has now been carried out and an initial assessment to its viability on a commercial basis has been completed, which suggests that it would be viable particularly if some charge for transport costs were passed and also if other waste materials associated with the fishing industry were also recycled. It would seem that the extension of the service established is a worthwhile exercise based on the benefit to the marine environment, as an alternative to sending to landfill and the positive re-use of the material in other industries. There is also evidence of a gradual change in attitude to waste disposal by industry when offered a route for recycling, which again is a positive outcome. A project looking at ways to recycled fishing gear into marine products has just commenced. This project is looking at manufacturing breakwater for a marina and also low drag trawl floats from recycled nets and will continue into 2011.

Fuel Efficiency

A study of the hydrodynamic efficiency of existing trawlers and ways of improving fuel efficiency by changes to hull design and hull appendages has been commissioned. This study is being carried out by Noel O'Regan of Promara Ltd, who has been working closely with BIM over the last few years on fuel efficiency initiatives. Tank testing of the modified hull designs will be carried out in early March 2010 in the facility run by the Wolfson Unit based in Southampton University.

Albacore Tuna Tagging

BIM carried out a satellite tagging programme for bluefin tuna in 2003 and 2004 which resulted in three giant bluefin being tagged for the first time in the Northeast Atlantic with migratory routes tracked from Donegal to Portugal, the central Mediterranean and the Bahamas. The technical knowledge gained from this programme has been used to tag Albacore tuna, a commercial species which has historically been underutilized by Irish vessels. Very short deployment periods were achieved for two fish released in 2008 but, with improvements in tagging technique, more successful deployments were achieved for two fish released in 2009. Fish 1 was released on 16 October 2009 off the southwest of Ireland and the tag remained attached to the fish for a period of 65 days before becoming detached and transmitting data southwest of Portugal). Analysis of the average depth of the fish during day and night revealed three distinct phases in diving behaviour as the fish moved south. This behaviour is similar to diving behaviour observed in archival tagged albacore in the North Pacific with a shallower distribution in summer related to shallow thermoclines and repetitive deep dives during winter when thermoclines are deeper. Fish 2 was released on 15 October and appears to have been eaten by a predator, given a sudden jump in temperature recorded, the failure of the device to record light level data for a period of about 9 days, and a dramatic change in depth preferences including sustained periods spent at or near the surface, before the tag was expelled, popped up and began transmitting data. This work has provided exciting new information on the behaviour of albacore in the North Atlantic for the first time. Now that the tagging technique has been perfected, more tagging earlier in the fishing season is needed to increase the sample size and provide more conclusive information on fish behaviour.

Acoustic Deterrents

A trial was carried out by in February 2009 to test if recordings of killer whale vocalisations could have a deterrent effect on common dolphins (*Delphinus delphis*), ultimately with a view to incorporating the sound into an interactive deterrent device developed by BIM for use in pelagic trawl fisheries. Seven pairs of different recordings from killer whales were used during the trial on groups of common dolphins located off the south coast of Ireland. Each pair of control and test signals contained background noise to ensure that if significant differences in response occurred that it would be possible to conclude that the dolphins responded to killer whale calls rather than any other sound stimulus. The background noise in the samples slowly increased in amplitude during the first 30 s, so as to avoid a startle response from the rapid onset of an unfamiliar sound. For the test sequence five killer whale calls from the same recording were spliced into the recording after 30 s. The control and test treatments were presented to the same group of dolphins in random order. During the first trial no evasive behaviour was observed during the test periods. As no reaction was observed a number of different killer whale sequences were tested subsequently but no changes in behaviour were recorded. A further study has just been completed in January 2010 on two further groups of dolphins off the southeast coast of Ireland. Again no effect was observed from either group.

Development of a fishery for Atlantic Saury

The Atlantic saury, (*Scomberesox saurus)*, is a fish of the family Scomberesocidae found in the Atlantic Ocean and also in the Mediterranean. It is an underexploited fish in many parts of its range and suitable for canning and other inexpensive uses. For a number of years Irish fishers have reported seeing large quantities of saury

around the Irish coast in the early autumn. Following some preliminary work in 2005 technical trials off the south west coast of Ireland were carried out in 2009 with lampara nets. The lampara is an artisanal method suited to smaller vessels which are able to fish in areas closed or otherwise inaccessible to larger boats by virtue of draft or similar restrictions. During daylight hours the method used to locate fish during was to observe feeding seabirds and to shoot around the area of the heaviest activity. This proved productive during daylight hours and small catches were made during the initial sets. At night the net was deployed with two submersible underwater fishing lamps using the natural behaviour of saury to be attracted to light. The night-time shots proved less productive, and there were some problems deploying the lampara net and the lights.

19.5 Italy

ISMAR-CNR

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Development of fishing Gears with Reduced Effects on the Environment (DEGREE)

The main goal of the project was to develop new gears/fishing techniques that have a lower impact on benthic habitats and to quantify the potential reduction of the physical impact as well as the negative effects on benthic communities. A new type of Mediterranean beam trawl was developed to replace the high impact rapido trawl used currently in the Adriatic Sea. The results of the trawling trials (both with Rapido and beam trawl) carried out off Ancona showed that a considerable fraction of the catch was composed of species of no commercial value, either because they were undersized or because they were unmarketable. Beam and Rapido trawl catches reflected the multispecies nature of the fishery in this area. In terms of biomass and abundance, catches were dominated by molluscs. Most of the Rapido trawl catch was discarded at sea (more than 55% and 80% of the catch respectively in the first and in the second cruise). While for the beam trawl the catch discarded at sea was around 50% (43% in the first and 59% in the second cruise). The Rapido trawl seemed to exert a stronger selective pressure on the macrobenthic community, being able to modify the epibenthic fauna structure. The Rapido trawl catch was characterized by species living strictly associated to or within the substratum whilst beam trawl hauls were characterized by a wider array of species inhabiting very different realms of the ecosystem (from benthic to demersal to pelagic). These differences were dependant both upon differences in species behaviour and differences in selectivity with respect to different species. The Rapido trawl was more efficient also for commercial species even if the performances of the light beam trawl improved during the second fishing trip. Recently some fishers agreed to use the light tickler chain beam trawl and they improved their performance increasing the vertical opening with the aim of catching demersal and pelagic species. It was observed that the mean duration of Rapido haul is around 50 minutes and this leads to very hard work for the crew. Thus a reduction of the time for sorting the catch represented a very good option for fishers. Moreover we noticed that the reduction of the discarded portion of the catch improved the quality of fish. In light of the results obtained in the current study the Italian door manufacture "Grilli" SAS and the CNR-ISMAR patented the experimental beam trawl which is now used by some fishing boats in the Adriatic Sea. Moreover a new door has been designed to reduce hydrodynamic drag coefficient and increase spread of door commonly used in the Mediterranean commercial demersal trawl fisheries.

Flume tank testing and engineering sea trials provide data which allow us to illustrate the performance and impact on the seabed of an existing door and a new door design. In the flume tank, each model was tested over a range of attack angles and for a limited range of otterboard heels. Curves of spreading, drag- and down-force coefficients have been calculated. In the case of sea trials in order to extract the hydrodynamic coefficients an analysis has been applied and a mathematical model was used to calculate a range of angles of attack. From analysing the differences between engineering sea trials and flume tank tests we have deduced some conclusions about additional ground contact forces on sea trials that affect the performance of the doors. Moreover, a comparison between reaction forces of the flume tank and the estimation of reaction forces at sea has been given. Finally, this study allowed us to notice important differences between traditional and experimental otterboards.

Research on the impact and performances of otter trawls

Following the results obtained and the methodology applied during the DEGREE project, the Fishing Technology Unit of CNR-ISMAR has conducted several additional sea cruises in order to test the impact and the performances of new doors (E-max, Midnight and Thyboron). The performances of the doors were measured using two electronic TEKKAL (Germany) load cells used to measure the warp loads. By means of the instrumentation mounted on this vessel, it was possible to measure some additional parameters. In particular a Doppler Log was used to measure the instant vessel speed in relation to the seabed, a torsio-meter measured the engine revolutions, the shaft torque, the shaft power and the fuel consumption of the main vessel engine. Very good results were obtained both with E-max and Thyboron otterboards. Moreover different types of angle sensors were used in order to evaluate the door angle during the tow. In addition to this methodology an innovative approach using Sidescan sonar was tested in order to evaluate the physical impact on the bottom and real-time performance of the towed gear.

Improving assessment and management of small pelagic species in the Mediterranean (SARDONE)

The project aims at developing a series of tools which will enable a better understanding, stock assessment and fishery management of small pelagic fish resources (anchovy and sardine) of the Mediterranean. The three major stocks and fisheries i.e. the NW Mediterranean, the Adriatic and the Aegean have been chosen. One of the main goals was to define and improve the selectivity of existing towed gears used to catch small pelagic fishes in the Mediterranean.

The improvement of trawl net selectivity has been approached in two ways:

- by an assessment of the selectivity of current pelagic trawls and further by evaluating the potential selective optimizations of both trawl design and rigging; and
- through a study of fish behaviour in an experimental trawl with a horizontal separator panel, which operated by segregating pelagic species entering the trawl. Pelagic species can be differently sorted in a trawl net according to their specific behavioural reactions to the gear or to their morphological (size) differences.

Energy Saving in Fisheries (ESIF)

Project "Energy Saving in Fisheries" (ESIF) aims at investigating potential technical and operational methods to address the need to reduce energy consumption and associated costs in European fisheries. The study started with an inventory of potential technical solutions and ongoing projects in the participating member states. CNR-ISMAR created a database of current gears and vessels. This initial benchmarking exercise provided an inventory of current gears being used and an understanding of current fishing practices. A typical bottom trawler spends a great part of a fishing trip actually towing the fishing gear. During towing, the drag of the vessel is low compared to the drag of the gear. The gear drag therefore has a large effect upon the overall fuel consumption of the vessel. The fuel costs for a typical trawler can be 50% of the total expenses on a fishing trip. This research aimed at the development of bottom-trawl designs, for the Italian fisheries, with reduced fuel consumption. The new designs include the use of a new high strength material and the use of larger mesh in net areas where no negative effect on the catching power is foreseen. Regarding energy consumption, the comparison of the performances of Total Warp Drag (TWD) and Fuel Consumption (FC) was carried out considering the relationship, with the other concerned parameters. The analysis showed that a linear dependence upon Towing Speed (TS) was reasonably accurate, but a better approximation was achieved by correlating the drag with the square of the TS. The second result of this analysis was that the other independent variable to be considered in the equation was the Trawl Mouth Opening (TMO). The use of further variables did not substantially improve the approximation of data. Considering an operational towing speed for a typical OTB (24- 40 m) of around 4.00 - 4.25 kts, we obtained a decrease in the drag of about 2,103,290 kg and correspondently a decrease in the fuel consumption of about 739 [l/h], using the experimental trawl.

The second adaptation tested during the project was the use of multiple trawl rig. Towing multiple trawl rigs is not a new idea. The fuel consumption on both single and twin trawling operations during the same fishing period was the same, but there was an increase of at least 30% in catch rates. Such increased catch rates of twin trawls system are cause for concern in terms of conservation if fisheries were to be managed with individual vessel quotas. The real challenge achieved in the current project consisted in measuring the fuel consumption of two fishing vessels in the vessel segment OTM 24- 40 m, and then produce absolute daily energy consumption. A prototype instrument, named CorFu meter (CorFu-m), conceived in 2007 at CNR-ISMAR Ancona (Italy) and developed in collaboration with Marine Technology Srl (Ancona) and Race Technology Ltd of Nottingham (England). The prototype is a result of research and development work based on design experience applied to improve all aspects of fishing technology sector. The CorFu-m system consists of three components.

1) Two mass flow sensors. The sensors use the Coriolis measuring principle, which permit them to operate independently of the fluid's physical properties, such as viscosity and density. It is an economical alternative to conventional volume flowmeters;

2) One Multi Channel Recorder;

3) One GPS data logger.

A huge amount of data has been collected, and downloaded every fortnight (fuel consumption and GPS data) for a total of 50 Mb/day. Gear performances and drag

have been measured separately on short cruises using the SCANMAR system to measure the gear performance e.g. door spread, horizontal and vertical net opening net; and electronic load cells to measure the total warp loads. All the instruments have been linked by RS232/485 serial ports to a personal computer, which automatically controlled data acquisition and provided the correct functioning of the system in real time through an appropriately developed program. In the experiment, besides collecting fuel consumption (mass flow), geo-referenced positions, speed all by haul, operation such as sailing, steaming, etc. was also collected. In addition data on catches per haul (i.e. commercial catch and species composition) was also collected. After the end of the ESIF project, thanks also to National funding, we will continue to make use of the measuring systems on board the selected vessels. Considering the high interest of the fishing fleet for the experimental CorFu-m fuel consumption system, it cannot be ruled out that we will try to monitor new vessels belonging to the Adriatic fishing fleet.

Assessment of the impact of twin trawl in the Adriatic Sea

Towing multiple trawl rigs is not a new idea. Such fishing method could be in various forms and it has been practiced in a number of countries, but has recently been adapted in Italy: in the last 3–4 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishers: "Americana trawl"). Using twin trawl, higher catch rates have been observed in shorter trips and higher quality of landed fish, which is a growing priority in the industry. However, Italian Ministry of Agriculture and Forestry (MIPAF) considers that the practice of twin trawling could pose a potential threat to stocks due to the sizeable increase in catch efficiency. This project aims at evaluating the performances and the physical impact on the seabed of twin trawls in the Adriatic Sea. Sampling at sea was carried out initially in order to collect information on the gear performance (traditional single trawl net and twin trawl), gear efficiency and gear impact. Multi-rig system was found to be very efficient when trawling in shallow waters, using the same doors as when single rigging but with shorter bridles. The results showed a higher impact on the seabed, high horizontal opening of the mouth and a greater swept-area during tow. On the basis of the results obtained during the project, the Ministry issued a Decree which regulated that bottom trawlers using twin trawls are obliged to stop their activity every week for one day before the bottom trawlers using traditional single rigs.

Assessment of the protected species bycatch in pelagic trawl (BYCATCH III)

This project aims at evaluating the bycatch of protected species in pelagic trawl fisheries. The second objective is to find solutions to avoid the bycatch of such protected species. Pelagic trawlers in the Adriatic Sea only target small pelagic species (Anchovy and Sardine). CNR-ISMAR carried out several observations on-board vessels, monitoring the catch and bycatch. In order to reduce the bycatch in pelagic trawl a modified TED (*Turtle Excluder Device*) was developed and adapted to a single boat pelagic trawl. The preliminary results are encouraging. Next step will be to test the TED in a pair trawl which is the main fishing method in the Adriatic Sea.

19.6 Netherlands

Institute: IMARES

Project: ICES research on pulse trawling

A number of studies was carried out in response to the ICES Advice of 2006 on cod (de Haan *et al*., 2008), small-spotted dogfish (de Haan *et al*., 2009), and benthic invertebrates (van Marlen *et al*., 2009a), after preliminary trials determining the work protocol, and characteristics of the pulse *in situ* (van Marlen *et al*., 2007). The results were reviewed by correspondence by ICES-experts and discussed at WKPULSE in February 2010. The outcome of this workshop was presented at WGFTFB 2010. In addition catch and bycatch was monitored on board a commercial beam trawler fishing with pulse trawls in 2009 (Steenbergen and van Marlen, 2009).

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Project: VIP SumWing

Comparative fishing trials were conducted on a beam trawler fishing with SumWings against a beam trawl towing conventional gear. The vessels towed on more or less parallel courses over a two week period in October 2008. The catches of both vessels were quite similar to a reduction in fuel consumption of 11%. The integration with pulse trawling will deliver further savings in fuel consumption (van Marlen *et al*., 2009b).

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Project: VIP HydroRig

This project started in 2008. The idea is to replace the effect of tickler chains used on beam trawlers with water flow stimulation. First attempts involved a wing-shaped beam deflecting the flow to the seabed. Later spherical cups were used to generate vortices in the wake. Laboratory tests at Deltares, Delft, Netherlands in 2009 showed potential. Sea trials gave positive results with reasonably good plaice catches and considerably fewer benthic organisms. Comparative fishing trials with direct observation were further completed in May 2010 in collaboration with ILVO Ostend Belgium. Unfortunately the skipper decided to go back to tickler chain beam trawling on sole under pressure of his crew, because catches were still lower than on vessels in their vicinity.

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Project: VIP Outriggen 2008

Two commercial beam trawlers were rigged with so-called 'outriggers', (small nets with otter boards replacing tickler chain beam trawls) during 2008 and 2009. Catches and bycatches were monitored in cooperation with ILVO Ostend. The method was found to be fuel efficient, and caught 1.4 times more plaice (*Pleuronectes platessa* L.). Catches of sole (*Solea vulgaris* L.) were considerably lower (16%) despite attempts to modify the gear to increase catch rates for this species. Fuel use was reduced by 55%. However, using 80 mm codends gave high levels of undersized fish bycatch. More details can be found in (van Marlen *et al*., 2009c).

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Project: VIP Passive Gear Development

A new project began in 2010 with three vessels operating passive gears. The objective was to develop a year-round fishery with this gear. A research programme was set up for each boat involving the use of gillnets, trammel nets, pots and jigging machines. Data will be collected using a predefined format and analysed by IMARES. Experience in Belgium (through ILVO) and Denmark will also be used.

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Project: VIP ViBOS

This project aims at developing a data collection and decision support system for fishers. Three beam trawler skippers are involved. The project is coordinated by Chartworx Ltd. of Den Helder, the Netherlands. The aim is to bring together data from various sources, e.g. DGPS, electronic sea charts with hydrographical data, vessel plotter, catches and bycatch (E-logbook), warp loads, fuel consumption, etc. The system will be made to optimize the skipper's performance in terms of catches, fuel use and effects on the marine ecosystem.

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Project: Bycatch Reduction by Technical Means (Dutch: VDTN-3)

Further experiments were conducted on FRV "Tridens" on Benthic Release Panels and Benthic Release Holes in November-December 2009. A total of 46 paired hauls were made with one conventional and one modified gear showing the potential of Benthic Release Holes. This work was also done in cooperation with ILVO in Belgium.

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Project: Energy Saving In Fisheries (ESIF)

Project "Energy Saving in Fisheries" (ESIF) aimed at investigating potential technical and operational methods to address the need to reduce energy consumption and associated costs in European fisheries. Participants came from: Denmark, Netherlands, Belgium, France, UK, Ireland and Italy. The team consisted of biologists, fishing gear technologists, naval architects, and economists. The project consisted of an inventory of potential technical solutions and ongoing projects, followed by economic data collection and appraisal of the identified solutions under various scenarios of fuel price. A large number of technical and operational measures were studied, among which: redesigned fishing gears including all their components to reduce drag (e.g. light material warps, more efficient otter boards, reduction in netting twine area, use of thinner twines, use of T90 meshes, hydrodynamically shaped beams in beam trawls), changing from twin to single rigs, converting from trawling to seining or from beam trawls to outrigger trawls, applying alternative stimulation of fish in gears to become susceptible to capture (electric pulses of manipulation of the water flow inside the net) to replace heavy bottom chafing material, optimizing propeller design (e.g. using a propeller nozzle, enlarging propeller diameter where possible), improving hull shape, adding a bulbous bow if not fitted, but also of operational nature such as: use of fuel meters, reducing steaming and towing speeds, maintaining engines properly, and cleaning hulls more frequently. For some of these quite substantial reductions in energy consumptions were found. However, at the current high fuel prices most adaptations did not result in net gains (van Marlen *et al.*, 2008; van Marlen and Salz, 2010).

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Project: Flatnose (FISH/2007/07 LOT3)

This EU-tender study aims at evaluating the impact on non-target and non-marketable species, including benthic invertebrates of fishing gears currently used to catch plaice and sole in the North Sea. It is meant to investigate (and if appropriate, recommend) the use of alternative fishing gears for the fisheries concerned, addressing ecosystem effects on various target and non-target species, as well as economy. A model developed by Piet *et al*. (2009) was adapted to this work and run for various scenarios of gear use (including selection parameters, gear dimensions and gear efficiency) to predict effects on landings and discards, and this information fed into an ecosystem model to predict the status of various stocks over time. The evaluation involves the use of otter trawls, beam trawls and static gears in a range of métiers (combination of vessel length class and gear used). The work is still underway and will be finalized in June 2010.

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Project: Development of fishing Gears with Reduced Effects on the Environment (DEGREE)

Thirteen participants worked together to develop new gears/fishing techniques that have a lower impact on benthic habitats, and to quantify the potential reduction of the physical impact as well as the negative effects on benthic communities; In addition to weigh the socio-economic consequences of these changes against those of alternative management measures, e.g. closed areas. They focused on the development of modified towed gears. A generic approach was chosen in which cases (e.g. North Sea, Mediterranean) can be developed. The overall ecological impact to benthic systems has been assessed by developing physical/biological models verified by sea trials. This provides a tool to fisheries managers to identify gear and sediment type combinations which will minimize impacts to the benthic habitat. A group of experts worked to appraise the socio-economic consequences of the new gears and techniques. Gear types under study involved: otter trawls, beam trawls, pulse beam trawls and dredges. The project consisted of six work packages and ran for 44 months, starting on 01/02/2006, and ending on 30/09/2009. Special emphasis was given to consultation with and dissemination of the results of the work to the fishing industry through national Industrial Liaison Groups and implementation plans for alternative fishing gears and techniques (van Marlen *et al*., 2010). Various new designs resulted of trawl or trawl components with fewer impact (e.g. plate gear replacing 'rock-hopper' groundrope in Norway, light beam trawl replacing 'rapido' in Italy, new oyster dredge in Denmark, pulse trawls and benthic release panels in beam trawling in Belgium, Netherlands and the UK, new doors and rigging in France, Ireland, Italy and the UK), and progress was made with predicting effects of gear and components on various sediments and subsequent effects on benthic invertebrates, although the work needs continuation.

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Project: Cooperative Research Platform

This project involves encouraging cooperation between the Dutch Ministry for Agriculture, Nature and Food Quality, the Dutch Fisheries Product Board and IMARES.

For several years, fisheries managers, fisheries representatives and fisheries scientists have been working on improving cooperation to facilitate better management of Dutch demersal fisheries. First there was the 'F-project', which aimed at improved stock assessment; better use of fisheries' dependent data; and communication between all parties (2002–2007). Then, in 2008, a platform for Cooperative Research was set up. In the platform, fisheries representatives, managers and scientists participate. Their common objective is to coordinate all ongoing projects that are relevant to management and to share information. Several issues are being dealt with in the Cooperative Research Platform, e.g. validity of research surveys, collaboration in discards monitoring, setting up an industry survey etc. This structural way of communication has improved cooperation between parties and has had a positive effect on innovative trajectories in fisheries management. The platform is funded by both the Ministry and the Product Board.

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Project: Industry involvement in research surveys

In the framework of the Cooperative Research Platform a new role was established for the industry in research surveys that are used for plaice and sole stock assessments (Beam Trawl Survey and Sole Net Survey). Fishermen helped to check the survey nets before the surveys started and fishers joined the survey on board the research vessel. This resulted in more insight in the surveys from a fishermen's' point of view and a higher quality of discussion between scientists, fisheries managers and fishers about the survey.

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Project: VIP Industry Survey: Phase 1

In 2009 the first phase of the Trajectory Industry Survey was carried out. In this project, fisheries managers, fishers and fisheries scientists are investigating whether an industry survey – in addition to research surveys – for plaice and sole would be useful. It is being investigated how such an industry survey should be set up and how the information could be used for future management of these stocks. The first phase showed that comparative fishing between research vessels and a commercial vessel is feasible and that there is sufficient support for an industry survey from (international) scientists, fishery managers and fishers. A request for funding of phase 2 was submitted in March 2010. In that phase the comparison of length frequencies of plaice and sole from commercial and research vessels will be completed.

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Project: Fishery Study Groups ('Knowledge Circles')

Fishery Study Groups are (study) groups of fishers who formulated challenges, questions or problems in their fishery. Together they look for solutions to make their fishery more sustainable: both from an economic and ecological point of view. There are currently 13 groups of fishers, working on various fisheries in the Dutch sea, lakes and rivers. Issues that are being dealt with are e.g. gear development (pulse trawl, SumWing, outrigger, fly-shooting, static gear, *Nephrops* trawl and shrimp (*Crangon crangon* L.) trawl), reduction of bycatch or discards, increasing knowledge of target species, reduction of fuel costs and improving cooperation between fishers and retailers.

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Project: Fishery Study Groups Flyshoot fisheries

Since 2008 a group of Dutch skippers from the North and the South (about 16 in total) using Scottish seine net gear are working together in a Fishery Study Group exchanging practical experiences and discussing problems. Besides communication and marketing aspects they are interested in improving their fishing techniques. A group of these fishers visited the Marine Research Institute and flume tank in Iceland, as well as netmakers. Technical questions relating to creating more sustainable fisheries and improving fishing techniques, with specific interest in the behaviour of seine ropes on different grounds were discussed. Flume tanks are too small for scaling these ropes (2 x 1500 m) correctly for model testing. It was investigated whether other facilities could be used, such as model basins used in naval studies (e.g. of MARIN the Netherlands) could be used instead, but this appeared to be too costly. Discussions are still ongoing about whether to make use of ROV's and/or underwater cameras or even mini-submarines for direct observations of seine net gear. The Dutch netmakers and skippers were also interested in user-friendly net design software. Contacts with SINTEF and Ifremer have been made.

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19.7 Norway

Institute Of Marine Research, Bergen

Unaccounted mortality of North Sea herring crowded and slipped in purse-seine fisheries

Full scale survival experiments carried out in the North Sea in May 2008 and 2009, have shown that the unaccounted mortality of herring *(Clupea harengus)* that have been exposed to crowding and slipping from a purse-seine, may be substantial. The mortality rate four to five days after crowding ranged from 1.8% in the least crowded to 50.7% and 52.0% in the most crowded groups. Control group mortality was low, between 0.9% and 2.0%. Blood samples taken during the experiments indicated that the herring struggle to maintain their water:water/salt balance after slipping probably as a result of scale loss and skin damage. These results suggest a need to revise the legislation on slipping in these fisheries.

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Analyses of commercial catches to study the effect of a seismic survey in Lofoten and Vesterålen summer 2008

Data from official databases of landed catches was analysed to investigate if 2D seismic exploration carried out in the Lofoten/Vesterålen area (northern Norway) summer 2008 had an effect on the local fisheries. Catch rates from before, during and after seismic activity was compared. Although the data were not optimal for this purpose, a decrease in the catch rates of saithe and haddock (*Melanogrammus aeglefinus*) caught by gillnets during seismic activity was observed, but the same effect could not be documented for the fisheries with longline, hook and line or Danish seine. The catch rates of red-fish (*Sebastes marinus*) and monkfish (*Lophius piscatorius*) increased during seismic activity.

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Mid-water trawling for gadoids in the Barents Sea

Due to increased concern about bottom impact from bottom trawling, research has been carried out to verify if midwater trawling techniques can be an economical and sustainable method for the trawler fleet to catch gadoids. Pelagic trawling for gadoids in the Barents Sea was prohibited in the late 1970s due to high catch rates of juvenile fish, but selective properties are assumed considerably better with present-day technical regulations prescribing both larger codend meshes and the use of size selective sorting grids. An experimental trawl with an opening of 60 m x 40 m and mesh sizes of up to 32 m in the fore part has been tested over the last three years. The results showed large spatial and temporal variability in the availability of cod and haddock to pelagic trawling. Pelagic trawl is therefore a supplement and not a replacement to

bottom trawling. However, when favourably distributed large catches were taken. When fished with a grid (Sort-V) and 135 mm codend mesh size, selection was comparable to that of a bottom trawl. Meshing of capelin in the net section with 400 mm or smaller mesh size was shown to be practically eliminated by the use of T90 or square mesh netting. Constriction of the extension of the trawl as catch builds up in the codend, however, hampered the passage of fish past the grid and into the codend. This was remedied by the use of 4-panel extension and codend. This stabilized the geometry of the trawl. The extension and top panel of the codend were made entirely of square mesh while the side and bottom panels of the codend were made of T90 meshes. Comparative fishing trials indicated that the selective properties of this codend were similar to that of the grid. Further trials will be made with this codend. Moreover, to avoid catching excessively large catches, a catch limiting device will be designed that will release surplus fish at the fishing depth.

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Density estimation of King Crab in the Neidensfjord base on underwater video and compared to pot and trawl

In August/September 2009 two sampling gears, pots and trawl used in stock assessment for king crab were evaluated. Firstly a video transact was performed with an underwater drifting camera rig and afterwards trawl and pot samples were taken in the same area. Based on this investigation the average area "fished" by pots was estimated to be 4631 m^2 and the trawl efficiency was estimated to 0.37.

Contact: Dag Furevik (dag.furevik@imr.no)

Buoyancy adjustment after swimbladder rupture in cod (*Gadus morhua*); an experimental study on the effect of rapid decompression in Capture-Based Aquaculture (CBA)

The aim of this study was to investigate function, survival rates and welfare of cod following experimentally swimbladder puncture in the laboratory, mimicking this phenomenon that consistently occurs during fishing operations for CBA. Anaesthetized cod (n=30) were experimentally punctured by use of a purpose made vacuum cylinder. Pressure reduction before puncture, puncture sites, gas evacuation paths, and repair mechanisms among other puncture characteristics approached previous findings. Most fish survived the procedure with mortality levels not different from control groups. In order to check whether or not experimentally punctured cod were able to refill their swimbladder a pressure chamber was constructed. In ten challenge trials one experimentally punctured and one control fish being subject to the same handling routines except for the rupture procedure itself were subjected to increased pressure from 1.1 to 5 bar (equivalent of going from near surface to 40m depth). At present, time intervals buoyancy status was determined by lowering tank pressure while observing tendency to sink or float. Results revealed that punctured fish (n=10) were able to secrete gas immediately after puncture, and that their acclimation rates were not different from control fish. The experiments added to the growing body of evidence that swimbladder puncture being the most consistent damage during capture processes for CBA has only minor, short-lived and reversible effects on fish welfare.

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University Of Tromsø: Faculty of Biosciences, Fisheries and Economics - The Norwegian College of Fishery Science

Does bait type influence on the size selectivity in the longline fishery for haddock?

We conducted a project in autumn 2009 to investigate anecdotal information from fishers who stated that fabricated bait from Iceland improved the size composition in haddock landings. The sea trials took place in eastern Finnmark outside the municipal of Båtsfjord September 2009. The design of the experiment was based on a comparison of three different type of bait; Mackerel (*Scomber scombrus*), Pacific saury (*Cololabis saira*) and a fabricated "BagBait"- from Bernskan Ehf, Iceland. We used series of 420 hooks (one tub) of each bait-type in settings of 24 tubs, 8 tubs with each bait-type evenly distributed. We length-measured all fish from the 96 tubs, i.e. 40,320 hooks, with 9,588 haddock in total. The results confirmed that lines with Pacific saury and BagBait caught larger fish than lines with mackerel. BagBait had the highest catch rate (fish per hook), followed by mackerel and Pacific saury. The results are reported have been reported to The Fishery and Aquaculture Industry Research Fund (FHF).

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Studies on bottom trawl dual selectivity

During March 2009 we collected data from the commercial bottom trawl fishery in the Barents Sea (i.e. 55 mm grid + 135 mm codend), using one cover to retain escaping fish from the 55 mm grid and another cover to retain escaping fish from the 135 mm codend. The method considers the parameter "grid contact" (C_{grid}), which measures the proportion of fish that actually comes into contact with the grid and has a real chance of escaping through the device. The selectivity of the grid and the codend could be estimated jointly and separately. This setup has been used in previous investigations (Kvamme and Isaksen, 2004; Jørgensen *et al*., 2006), but the total selectivity of the system in this studies was either modelled as a simple logistic curve or the model used did not consider C_{grid}. The results of the study showed the importance of estimating C_{grid}. The parameter was estimated to be between 0.76 and 0.85 for cod and ~0.95 for haddock. These results are corroborated by underwater video recordings of the grid. Behaviour studies carried out at the University of Tromsø recently showed that not all the fish come into contact with the grid and that haddock are more active behaviour inside the trawl than cod (Tschernij and Suuronen, 2002; Grimaldo *et al*., 2007). The results have been submitted to a scientific journal.

Harvesting zooplankton

During May 2009 we continued experiments/sea trials on the NRC funded and SINTEF F&A led project "Harvesting zooplankton by bubble flotation". More information on bubble plume formation and its effect on concentrating zooplankton and avoiding bycatch were gathered. The experiments were combined with fishing experiments with a new generation zooplankton trawls (50 m^2 opening area). The overall results show that air bubbles can improve fishing efficiency and to some extent reduce bycatch in the fishery (i.e. jellyfish, fish larvae, fish eggs, and various plankton). The results have been submitted to a scientific journal.

New coastal longliner

Since 2009 we've been involved in the planning of a new generation coastal longline vessel. The new boat will include latest features on Icelandic speed boat technology and modern hauling technology. The project will finish by the end of 2010. SINTEF F&A is partner in the project.

T-90 codend selectivity experiments

During March and April we conducted sea trials/selectivity experiments with a T-90 codend of 135 mm mesh size in the Norwegian bottom-trawl fishery. The results obtained for cod show that the variation in the data within the cruises is not very big. However, the difference between the cruises is significant at 95% confidence. In addition, the data from cruise 2 showed a significant catch effect for both L50 and SR. "Catch" is negatively correlated with both L50 and SR. This effect was neither significant for cod nor for haddock during cruise 1. However, the data for cod in cruise 1 showed a similar trend. L50% and SR for cod in March were 53.4 cm and 8.6 cm, respectively. In April the values on cod were 58.8 cm and 11.4 cm. For haddock valid results were only obtained during March, with L50% = 51.3 cm and SR = 7.4 cm. Results from video recordings show that the T90 codend moved violently during fishing and that the codend panels were "wavy" instead of properly stretched. It was not clear how and when fish escaped the T-90 codend.

Studies on gear parameters in longline fisheries

Since April 2010 we've collected data from two coastal auto line vessels (11 and 15 m l.o.a) studying parameters like main line thickness (7.2 mm and 9.0 mm), snood material (PA mono and twisted PES) and bait type vs. catch rates. The data collection is still in progress and no results have been analysed as yet.

SINTEF Fisheries and Aquaculture

Fatal accidents in the Norwegian Fishing fleet

SINTEF have been studying the main categories of fatal accidents in the Norwegian Fishing fleets for a number of years as shown in Figure 22 and Figure 23. The main categories are:

- **Foundering;** lives lost when loss of vessels like water filling, capsizing, grounding, collisions etc.
- **Overboard accident;** falling or pulled (or jumped) over board on the fishing ground or at steaming and drowning
- **Harbour accident;** fishers falling in the water and drowning when the vessel is anchored in the harbour
- **Crushing or blow by gear;** fisher is fixed in the rope or net and goes into the hydraulic winch or drum and wounded or killed
- **Hit by falling or flying objects**; mostly on board bigger vessels with heavy fishing gear like trawlers
- **Fire, smoke, gas or electric current;** happens, but few lost lives
- **Other accidents** like falling on deck or to a lower level
- **Accidents at leisure time;** like drowning or traffic accidents (not included in this statistics)!

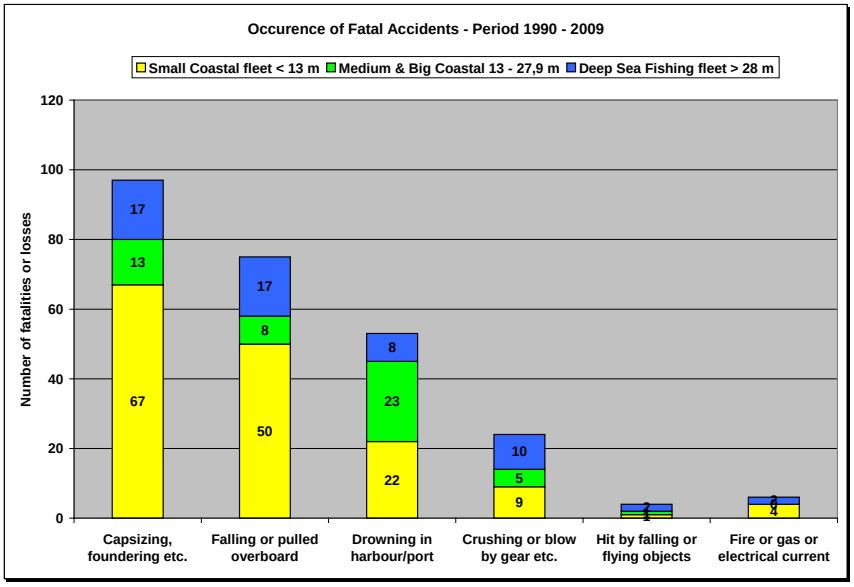

Figure 22. Occurrence of Fatalities in the Norwegian Fleet 1999–2009.

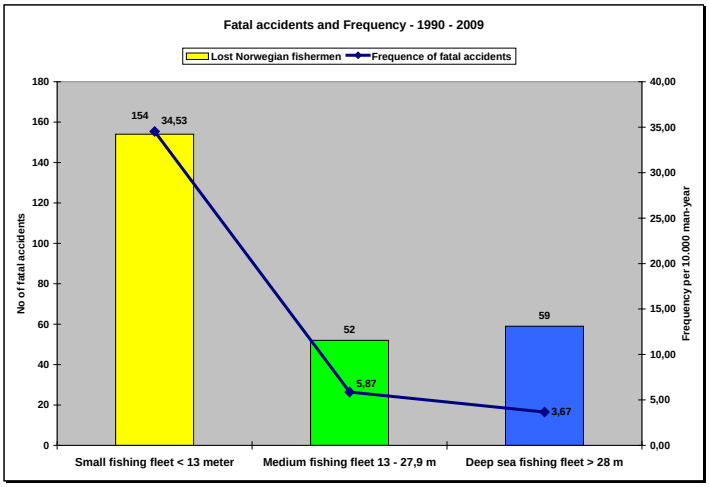

Figure 23. Frequency of Fatal Accidents 1999–2009.

Fatal accidents – risk relations 2000 - 2009

- **Fatal accidents – 10-year period 2000 - 2009:**
  - Agriculture: 100 perished – calculated risk: 0.153
  - Fishing fleet: 77 perished – calculated risk: 0.615
  - Aquaculture: 8 perished – calculated risk: 0.178
  - Offshore fleet: 11 perished – calculated risk: 0.125
- **Some risk relations:**
  - Fisheries vs. Agriculture: 4.0 times more risky
  - Fisheries vs. Offshore: 4.9 times more risky
  - Fisheries vs. Aquaculture: 3.5 times more risky
  - Agriculture vs. Offshore: 1.2 times more risky

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Harvesting zooplankton by use of air bubbles

In recent years there has been increased interest in exploitation of marine zooplankton like copepods and krill. The goal of this project is to study the use of air bubbles to lift *Calanus* to the sea surface to be skimmed by an oil spill recovery type skimmer, or to concentrate *Calanus* closer to the surface to be collected by a trawl with reduced opening area. When a large number of air bubbles are released into the sea the rising bubble plume will also induce an upwelling water flow. This may be used to lift and concentrate small particles and organisms towards the surface. *Calanus* have limited mobility and will generally follow such an upwelling flow. At the surface the upwelling turns to a horizontal out welling, and further out the water eventually sinks down. The *Calanus* must therefore be collected before it is brought outwards or it sinks back down. This can be done by traditional fine-meshed plankton nets or trawls, or skimmer-like devices as used in oil spill cleanup. The starting point for the project was that single bubbles would attach to individual *Calanus* and lift them towards the surface due to the bubble's buoyancy. Such a process is called flotation. Flotation was observed in laboratory experiments, but not sufficiently frequent. The upwelling mechanism, however, was observed to be efficient. In practice, flotation and upwelling will both contribute to lift *Calanus*. The bubbles are released on a given depth by supplying high pressure air to a system of porous sprayers. The efficiency of the system depends mainly on the release depth, the air flow rate, the design of the sprayer system and the towing speed, Oceanographic conditions such as stratification may also be important. A bubble sparger system was towed at 15 m depth at 1 knot during field trials with RV "Jan Mayen" in Lofoten and Vesterålen in spring of 2009. Arrays of plankton nets upstream and downstream the sprayer system showed that the concentration increased by a factor up to 20 in the upper 2–3 meters of the water column. The project is supported by the research Council of Norway through the *Oceans and Coastal Areas* program. In addition to SINTEF the Norwegian College of Fishery Science, NTNU, Calanus AS and UCSB participates in the project. The project has run since 2007 and is to finish in 2010.

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New fuel and catch efficient active fishing gear concepts based on trawl and seine

A project began in 2009 and is due to run to 2012, with the aim of reducing NOx- and other environmental emissions and impacts from demersal fisheries, by proposing new fuel and catch efficient active fishing gear concepts based on trawl and seine technology. The project aims to develop new rational fishing strategies and develop new, feasible gear concepts in close cooperation with fishers and the fishing industry, through workshops, lab tests and numerical simulations, including aspects such as net design, towing resistance and catch efficiency, including among other things a PhD in Operational Analysis. A workshop was held in Hirtshals in December 2009, resulting in a matrix of potentially interesting combinations of nets, spreading devices and groundgear for bottom trawls, (semi-)pelagic trawls and (Scottish) seines. A dynamic trawl simulation tool is being extended to handle seine-like operation.

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Improved vessel design and operation (Improved)

Modern ships and vessels for marine operations are equipped with a considerable range of sensors monitoring on board systems like for instance propulsion, engine, electrical power, deck machinery and other auxiliary devices. In addition, other systems (i.e. fish handling and storage, state of cargo, navigation parameters, ship motion and certain environmental parameters) are or may be monitored. If such measurements can be analysed and stored in a structured way, it may be of high value for several applications: First, for optimization of ship operation both on a daily basis and at a strategic level for ship owners. Secondly for improving the design of future vessels for comparable operations. In addition, there may be several side effects of providing such detailed information from operating vessels - for instance the possibility of accommodating maintenance programmes and classification schemes for the vessel's systems, or for documentation of emission of greenhouse gases (GHG) and other environmental impacts. The problem to be addressed is to provide solutions where on-board measurements are systematically acquired, validated and aggregated. This aggregation may be performed both for individual ships, a shipowner's fleet and in a national database. Such a database would offer important and long-lasting possibilities for future improvements in the fishing and offshore business. Important issues in building such a database are how to collect the data material, and how to reduce its volume while maintaining the necessary details. The presentation could be done for example as key performance indices (KPI) for optimal ship operation with respect to energy efficiency and emission of green-house gases (GHG). Another issue addressed by this project, is how available information can be utilized to improve the operation of the vessel at hand. In addition, methods and tools for decision support and ship design will be developed. This project is to be started in 2010.

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19.8 Portugal

Institute: INRB IP/IPIMAR

Analysis of the Portuguese coastal trawlers fleet dynamics based on landings composition and vessel monitoring system (VMS) data

Fishery-dependent information, including geo-referenced information from the Portuguese vessel monitoring system (MONICAP) combined with landings data, was used in order to identify a reference fleet. This fleet is composed of vessels collecting high-quality data in terms of landings and vessel monitoring system (VMS) records and representative of the landing profiles (LP) previously identified. This information is being processed in order to estimate, among other things, species-directed effort and fishery-based abundance and productivity indices for commercial species. Market sales and vessels characteristics, including aspects of vessel operation, are being added to the analysis, allowing an understanding of the importance of fish abundance, operational aspects and market conditions in fleet dynamics and fishing tactics. In addition the data will be used to describe the existence of a number of distinct landing profiles with different species composition in terms of target and bycatch species. Fishery-based data used was supplied by the Portuguese General-Directorate for Fisheries and Aquaculture (DGPA) following a protocol created between DGPA and IPIMAR. Processed VMS data were made available to this study by the Univer-

sity of Algarve, through a computer application (GeoCrust 2.0, Afonso-Dias *et al.*, 2004; 2006).

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Software development for the estimation of total trip fuel consumption in coastal fishing vessels

Important savings may be achieved by improving fuel management on-board fishing vessels. A software application is being developed aiming at the estimation of total trip fuel consumption for coastal fishing vessels (trawlers, gillnetters and longliners, and purse-seiners) based on the vessel characteristics and on the trip scenario parameters. Total fuel consumption and hourly fuel rates are also estimated for the different phases of the fishing trip (steaming, setting and hauling the gear, trawling) as well as the total amount of emissions generated during that fishing trip. The application will allow varying systematically the values of the fishing trip parameters to achieve a better fuel management and control of gas emissions.

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19.9 Scotland

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300 and 600mm netting in the front sections of a Scottish whitefish trawl

During 2009 experimental trials were conducted to assess the extent to which cod bycatches in the Shetland mixed whitefish fishery would be reduced by replacing the 120mm netting in the front sections of a trawl with 300 and 600mm netting. A further aim was to assess the effect of these modified trawls on the catches of monkfish and megrim, which are economically important to the Shetland fleet. The results showed that both test gears caught significantly fewer cod, hake, megrim and ling than the control trawl across all length classes and significantly fewer monkfish below 76 and 83cm respectively than the control trawl. The 300mm trawl caught significantly more haddock than the other trawls and catches of saithe greater than 53cm were reduced in both test gears.

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Swedish grid and 120mm square mesh panels trials in the Scottish *Nephrops* trawl fishery

Two sets of trials were conducted, on the west and east coasts of Scotland, to estimate the selectivity of an 80mm diamond mesh codend fitted with (i) a 35mm Swedish grid, (ii) a 120mm square mesh panel (SMP) at 6 – 9m from the codline and (iii) a 120mm SMP at 12 – 15m from the codline. The main results were:

i) The Swedish grid gear retained all *Nephrops* < 40mm carapace length and between 75 and 90% of *Nephrops* ≥ 41mm

ii) The SMP gears retained between 70 and 88% of *Nephrops* below about 37mm and all *Nephrops* ≥ 40mm.

iii) The grid gear retained fewer whitefish than the SMP gears. No cod > 34cm, haddock > 35cm, whiting > 38cm and hake > 41 cm were retained by the grid gear.

iv) The position of the SMP had no significant effect on the retention of *Nephrops*, cod, haddock, or whiting.

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120, 160 and 200mm Square mesh panels in the extensions of Scottish demersal trawls

Three sets of catch comparison trials to investigate the selective performance of 120mm, 160mm and 200mm SMPs positioned in the extensions of Scottish demersal trawls were carried out in conjunction with the Scottish Fisherman's Federation during 2009 - 2010. The first set of trials compared a whitefish trawl fitted with these SMPs with the standard 120mm x 5mm double codend with no SMP. The second compared a *Nephrops* trawl fitted with these three SMPs with the North Sea standard 80mm diamond mesh codend of 4mm single PE twine with a 110mm square mesh panel (SMP) positioned 15 – 18m from the codline. The third compared a *Nephrops* trawl fitted with 160 and 200mm SMPs with the West of Scotland standard 80mm diamond mesh codend of 4mm single PE twine with a 120mm square mesh panel (SMP) positioned 12 – 15m from the codline. In general, the 200mm SMP gears were more selective than the 160mm SMP gears which were more selective than the corresponding control gears. The 120mm SMP gears was not shown to be significantly more selective for any species in any of the trials. We must, however, be cautious when comparing results between trials, for in each set the control with which the test gears are compared differed and very often the length range of the population fished varied.

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300, 600 and 800mm diamond mesh belly panels in Whitefish trawls

Catch comparison trials were carried out in February 2010 to investigate the selective benefits of inserting 300mm, 600mm and 800mm diamond mesh panels in the belly sheet of a whitefish twin-rig trawl. Commercial fishing grounds at the E and N Holes, approximately 40 to 50 nautical miles east of Lerwick on the Shetland Islands, were fished throughout the trials. In general the 800mm panel gear caught less than the 600mm panel gear, which in turn caught less than the 300mm panel gear. The 800mm panel gear caught fewer cod, megrim and monkfish than the control trawl and there is pointwise evidence ($p < 0.05$) that it catches fewer whiting > 36cm and haddock > 39cm. The 600mm panel gear also caught fewer cod, megrim and monkfish than the control trawl. It seems to catch more, smaller haddock (< 30cm) and there is no evidence that it affects whiting. The 300mm panel gear catches more, smaller haddock (< 33cm) and fewer haddock > 44cm and there is pointwise evidence ($p < 0.05$) that it releases cod in the length range 47 – 53cm. There is no evidence that it affects whiting, monkfish or megrim.

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35 and 40mm Swedish grids in a Scottish *Nephrops* trawl Fishery

Trials were conducted in 2010, on the east coast of Scotland, to estimate the selectivity of an 80mm diamond mesh codend fitted with a 35mm Swedish grid and one fitted with a 40mm Swedish grid. The relative catch rates of both grid gears were signifi-

cantly different from the 40mm control codend for haddock, whiting, *Nephrops*, plaice, witch, megrim and hake. In addition the catch rates of haddock and hake in the 35mm grid gear were different from those in the 40mm grid gear with the 40mm grid gear catching more haddock and hake. Both grids were very successful in eliminating catches of large fish and no haddock, whiting or hake greater than 35, 38 or 39cm were caught by the 35mm grid gear and none greater than 45, 41 and 47cm by the 40mm grid gear. For *Nephrops* the relative catch rates of the two test gears were not significantly different from each other.

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The influence of two different groundgears on the Catchability of the deep-water survey gear (bt184) while deep-water trawling

"Bagging" trials were carried out to assess selectivity and sampling bias/catchability of the deep-water survey gear with 2 different groundgears (21" vs. 16"rock-hoppers) on the deep-water slope of the Rockall Trough, NE Atlantic. The means of assessing catch efficiency was to attach an auxiliary set of nets underneath the groundgear which captured fish escaping or being forced underneath the net. The data suggested that up up-to 58% of the entire catch was being lost with clear species biases in the losses that occurred. Reducing the diameter of the rock-hoppers on the groundgear reduced both losses and species selectivity, although a significant proportion of the catch was still lost.

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Fish Pot Development

Trials were carried out in April 2009 in support of a research cruise on RV "Alba na Mara" dedicated to developing survey techniques for inshore waters (in and near Loch Ewe). The fish pots were compared against of samples techniques (namely, trawl and baited cameras) and proved more successful in providing quantifiable numbers of fish, as well as demonstrating differences in species assemblage at relative high resolution (i.e. sampling stations were approximately 1 nm apart). These and previously collected data are being analysed by an MSc student and further investigations regarding bait are about to take place.

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Benthic Impact and sediment resuspension

Trials were held in conjunction with Leeds University to calibrate readings between a LISST 100X and Reson 7125, from the sediment plumes created behind towed objects on different sediment types. On these trials a roller clump and a trawl gear were towed from the "Alba na Mara" and the concentration of sediment mobilized in the wake measured (i) by divers in the TUV using a LISST 100X and (ii) acoustically, using a Reson 7125, that was mounted on a chartered vessel. The trials were very successful and the data are at present being analysed.

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19.10 Spain

Institute: AZTI Tecnalia

Contact: Luis Arregi (larregi@azti.es)

Development of a fuel management system for improvement of the fuel consumption pattern in fishing vessels

The main aim of this project is to improve fuel efficiency on fishing vessels. In order to characterize accurately the pattern of fuel usage on board, a complex consumption measuring system has been designed, capable of recording not only the fuel consumption but also many other interesting variables, such as wind force and direction, the exhaust gas temperature, the rolling and pitch movement and the vessel speed. The information given by each sensor will be recorded every second in a computer. This will allow calculating how much fuel the fishing vessel consumes in each part of the fishing operation. The installation of the measuring system has been carried out in 4 vessels from 3 fleet segments where fuel consumption is the highest (trawling, purse seining and trolling). The system has been running for practically a year. The results have been very satisfactory and have brought fuel consumption reductions of up to 15% depending on the fishing segment. After this period we have reach several different conclusions. The main conclusion could be that it is not necessary such a complex system is needed to bring benefits to the user and now we are developing a lower cost system that will assist the fleet in the fuel consumption management on board.

MarineRC, recover of the energetic losses from waste heat from thermal engines

The main goal of this project is to develop a system that allows the recovery of part of the waste heat in diesel engines to generate electric energy or to move other mechanical gear. In this way a reduction in fuel consumption can be potentially achieved and at the same time emissions to the atmosphere will be reduced. Basically the project involves the development of a system that utilizes heat loss in the exhaust gases and in the cooling water to move an expander which generates mechanical energy that produces electric energy to power other mechanical devices.

MarineFUEL, experimental tests on alternative fuels for the fishing fleet coming from recycled lubricant oils

The main goal of this project is to characterize the combustion characteristics of a new alternative fuel oil coming from recycled oils in a test bed and to compare with traditionally distilled fuel oil in controlled conditions and to define if it is possible to use this in fishing boats. Afterwards if the results are positive a pilot test would be done on a commercial vessel.

EFIOIL

This project focused on fuel efficiency consists of five subprojects:

- ORC: Organic Rankine Cycle. Development of an experimental Organic Rankine Cycle with a scroll expander for recovering waste heat from cooling water and exhaust gases.
- AUDITOIL: Development of energy audits for fishing fleet.
- HELIZAK: Measurement of propeller thrust for efficiency evaluation.

- HOBEBIDE: Development of a tool for weather routing in Basque fishing fleet.
- BULBOS: Evaluation of bulb installation in Basque fishing fleet via CFD simulation and water tank tests

Design and trial of a new trawl net to reduce fuel vessel consumption in the bottom-trawl fishery targeting multispecies in ICES VIIIabd

Thinner and robust netting materials that can reduce the drag of trawls and hence improve fuel efficiency are available on the market for the construction of fishing nets. A modified design of a commercial bottom-trawl net has been designed and built with half of the upper part of the trawl replaced with high tenacity polyethylene netting not including the codend. Preliminary trials at sea were carried out in 2006 to establish the working method for assessment of the hydrodynamic performance of the trawl system, catching efficiency and fuel consumption of the towing vessel during fishing. The preliminary trials identified that there is margin for fuel consumption optimization while keeping similar catch rates for the target species. Further improvements in trawl design and trawl fishing system have been carried out in 2008 and modelled prior to trials at sea, that were carried out in 2009 to evaluate net geometry, catching performance, fuel efficiency and operation on deck for the new trawl.

Technical and economical study on the potential fuel efficiency improvements of hull and propeller modifications

When a boat is sailing at a constant speed, the driving force of the propeller is balanced by the force resisting motion. The main objective of this study is to evaluate the suitability of changing the propeller and hull appendage design in order to reduce fuel consumption, either through optimizing the propulsion system or improving the hydrodynamic characteristics of the hull. A classification in different groups has been carried out among all the fishing vessels of the fleet looking at hull design and fishing operation. From a sample of several fishing vessels, representative of each group, all the possible modifications on the hull are being studied and designs of new propellers are being carried out. Although many of the modifications studied will not be executed during this project, their estimated improvement in fuel efficiency will be estimated based on naval engineering methods. Preliminary results show that bulbous bows improve the fuel efficiency in larger vessels. Similarly matching propeller to hull design also helps in fuel efficiency and finally correctly trimming the vessel has been found to be another important factor.

Reduction of the discards by mean of selective devices in the "baka" single bottom trawl

In this 2 year project starting in 2009 we will try to reduce discarding in bottom trawlers operating in ICES VIIIabd by means of selective devices. In the first part of this project an underwater video camera will be set in different parts of the trawl to study the behaviour of different species. The footage obtained with the camera will contribute to deciding upon the most suitable part of the trawl to install appropriate selective devices.

Quantification of the discards and improvement of the selectivity in the artisanal fisheries

In this 3 year project started in 2009 a characterization and quantification of discarding in the different gillnet artisanal métiers, will be carried out in order to identify the ones with the highest discard rates. Following an analysis, possible methods to reduce the bycatch of the more frequent discarded species will be investigated. Finally, fishing trials these selected methods will be tested.

Identification of the technological creep since 1950 in some of the most traditional fisheries for the Basque fishers

In this project, retired skippers will be interviewed in order to identify the technological creep in the fisheries they have been involved. Three fisheries have been selected: anchovy with purse seining: tuna with pole and lines and trolling lines; and tuna freezers with purse seining in tropical waters. For each one of these fisheries all the technological improvements introduced in the fishery will be identified and characterized. Following, a description or quantification of the importance of each of the technological changes, in terms of increase of the catches, will be carried out.

Institute: Instituto Español de Oceanografía (IEO)

Contact: Juan Santos (Juan.santos@vi.ieo.es)

Strategic Spanish Project relating responsible fishing on discard reduction (REDES)

A Gap Analysis of fishing technology has been completed in Spain recently. REDES is a multidisciplinary project funded by Spanish Science and Innovation Ministry and the EU, which began in 2009 to try to address the gaps identified. REDES involves fishermen's' associations, ship-owners, technology industries, research institutes and university departments in a collaborative way .The project will deal with several Spanish fleets, known to produce high discard rates. Description of the partnership is showed below:

- The fishing industry is represented by two of the main Spanish associations (ARVI and CEPESCA), linking the fleets that will have to face relevant discard's reductions with the project.
- Other key industrial partners in REDES are those companies having to deal with fishing gear and fishing technology. TECNOPESCA PYM and MAREXI are two Spanish SME´s that will lead the implementation of new ideas into specific products feasible for target fishing units.
- RTD activities needed for such an ambitious and multidisciplinary project design is being carried out involving up to eight different research groups from five different public research institutions such as the Spanish Institute for Oceanography (IEO), the University of Vigo, the University of A Coruña, CETMAR Foundation and the CEHIPAR Flume Tank (this is to be hired by the University of A Coruña, due to technical and administrative reasons).

REDES has been designed as an integrated project comprising the following subprojects:

- SP1 - Analysis of the distribution, performance and factors influencing discarding in Spanish fishing fleets operating in the North Atlantic and Mediterranean fisheries.
- SP2 - Design and construction of selective fishing gears and devices. Including the so-called "Design Centre", a meeting point between fishers, technicians and scientists.
- SP3 - Simulation, testing and re-design of new fishing gears and devices.
- SP4 - Analysis of selectivity and the major effects expected from the introduction and use of selective fishing gears.
- SP5 - Project Office: Coordination, dissemination, contribution to standardization and technology transfer support.

19.11 USA

Massachusetts Division of Marine Fisheries - Conservation Engineering Program

Contact: Michael Pol (Report compiler; mike.pol@state.ma.us), David Chosid and Mark Szymanski

Development of a Spiny Dogfish Excluder in a Raised Footrope Whiting Trawl

A spiny dogfish *Squalus acanthias* excluder grate (grid) was designed and tested within the codend extension of a silver hake (whiting) *Merluccius bilinearis* net, assisted by live-fed underwater video footage. Grate colour (white or black), angle, and direction (leading to a top or bottom escape vent) were investigated. Nine pre-trial and 24 true trial tows achieved strong reductions in spiny dogfish with substantial catches of target species for all gear configurations based on video observations and catch; four tows (of various gear configurations) resulted in spiny dogfish blockages in front of the grate. The quality of marketable catches seemed to benefit from the reduction of the spiny dogfish.

Determining the Seasonality of Cod Pots

Newfoundland-style, large, large-mesh static pots were compared to Norwegian-style smaller, small-mesh, off-bottom, dynamic pots in a controlled study from a commercial fishing vessel from November 2008-November 2009. Results from analysis indicate that cod were most vulnerable to pots during a limited season, and that the smaller mesh pot caught more small cod. Otherwise, the pots performed similarly. We conclude that either pot style may be effective for further development, that seasonality plays an important role and should be exploited for further testing, and observation of near-field behaviour in cod near pots is still vital and problematic.

Small Experimental Longline Fishery for Haddock using Norbait in a Cod Conservation Zone

Four commercial demersal longlining vessels targeted haddock *Melanogrammus aeglefinus* using manufactured bait, Norbait 700E, in an area closed to protect Atlantic cod *Gadus morhua* off the coast of Massachusetts, USA. Thirty-one trips in April 2009 landed 6708 haddock and discarded 43 haddock; 262 Atlantic cod were discarded. The overall ratio of cod to kept haddock was 0.038, or greater than 25 landed haddock per cod. All vessels performed better than a defined threshold of 0.1 ($p<0.05$). Causes of significant differences between vessels could not be determined as depth,

hooks fished, soak duration, and hook types interacted. Ratios were an improvement over a bait comparison study conducted in 2008 in the same region using Norbait 700E. Revenues were similar between vessels, although costs appeared to be higher for two using tub gear.

NOAA Fisheries, Northeast Fisheries Science Center (NEFSC), Protected Species Branch, Woods Hole, Massachusetts

Contact: Henry Milliken (Henry.Milliken@noaa.gov)

(Projects funded by NEFSC)

Scallop Dredge Comparison Study

Sixteen commercial fishing trips compared the Cfarm turtle excluder dredge design to the standard New Bedford dredge, with both dredge types rigged without turtle chains. The Cfarm experimental dredge reduced the number of support bars on the bale and changed the geometry of the dredge frame by moving the cutting bar forward. These trips entailed 154 days at sea and 1675 tow pairs observed for turtles, 841 of which were sampled for catch. During these tows, three turtles were taken by the turtle excluder dredge and three turtles were taken by the standard dredge. Insufficient data were collected to test the hypothesis. More trips are needed to understand the ability of this dredge design on reducing injury and mortality possibly resulting from benthic sea turtle interactions and resulting catch.

Contact: R. Smolowitz and M. Weeks

Assessment of the bycatch rates of harbour porpoise in large mesh monkfish gillnets hung with a primary hanging ratio of 0.5 and 0.33

This project has just been completed, and the final report is expected before October 2010. As of the end of October 2009, half of the testing (79 out of 160 hauls) had been completed, but was not sufficient to determine whether there was a different catch rate of harbour porpoise between two hanging ratios (0.5 vs. 0.33) in sink gillnets. The latter half of testing was scheduled to start in February 2010. Twenty-eight marine mammals were incidentally caught during the first phase of this study. Most of these encounters occurred in gillnet panels hung with both treatments, which we determined were not catching similarly to gillnets hung with only one treatment.

Evaluation of the catch performance of the NMFS flounder Turtle Excluder Device (TED) with a large opening in the Southern New England whiting trawl fishery

Previous studies of the catch performance of bottom trawls equipped with NMFS certified flounder TEDs in the mid-Atlantic region have documented losses of target species ranging from 35% in summer flounder fishery (TED was 32x51 inches) to 7% in the sea scallop fishery (TED was 43x51 inches). This study documented a 22% loss of whiting or silver hake (*Merluccius bilinearis)* in the directed whiting trawl fishery, and a statistically significant loss based on 16 paired tows. The use of the TED resulted in a statistically significant 27% loss of flounder catch. There was no significant effect on catch performance as a result of using the TED on the skate complex, the dogfish complex, and butterfish; however these latter species were not captured in sufficient number for robust statistical analysis.

Contact: J. DeAlteris and C. Parkins

Evaluation of the catch performance of the NMFS flounder Turtle Excluder Device (TED) with a large opening in the US Mid-Atlantic scallop trawl fishery

A previous study conducted in 2006 of catch performance of a NMFS certified whelk TED in the sea scallop trawl fishery documented a 7–8% on average loss of the target species depending on the net design, and a low bycatch rate of other species. The results of this study of the catch performance of a NMFS certified flounder TED installed in a scallop trawl net documented similar results. In leg 1 with 18 paired tows, the scallop loss was significant (7%). The result of leg 2 conducted on a different vessel documented a similar loss, but it was not significant likely due to a smaller number of replicate tows (n=9). Leg 3 included the use of an additional extension section ahead of the TED extension section, and the loss of scallop increased to 13%, but there was not a significant difference between the TED mean catch of scallops and the control catch of scallops again likely due the low replicate sample size (n=9). Total discarded bycatch in the fishery including shells, sponge, crabs, fish, etc ranged from 7–15%, and skate was the dominant fish bycatch at about 4–7% of the total catch. Skate catch was reduced significantly with the use of the TED in leg 1 but not significantly in legs 2 and 3, again likely due to the smaller replicate sample size.

Contact: J. DeAlteris and C. Parkins

Study on catch retention using a larger TED in summer flounder trawl fishery

See entry for Gulf of Maine Research Institute, below.

Projects planned for 2010

The NEFSC plans to contract the assessment of the impacts of gear modifications in the monkfish *(Lophius americanus*) fishery on bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and harbour porpoise (*Phocoena phocoena*). We also plan to conduct a workshop on mitigating sea turtle bycatch in the mid-Atlantic and southern New England trawl fisheries: past and future developments. Discussions from this workshop will help in the development of research priorities to mitigate sea turtle bycatch in trawl fisheries, also being funded by the NEFSC. The NEFSC is working with Cornell University on a project titled: A Method To Reduce Butterfish Retention In The Offshore Directed Loligo Squid Fishery Through The Use Of A Bycatch Reduction Device (BRD) Adapted To Pre-Existing Gear. The NEFSC is working with other NMFS Science Centers, Woods Hole Oceanographic Institute, and Coonamessett Farm to develop a robust underwater camera system using digital recorders that are capable of viewing frames or "snapshots" of video imagery.

Other NEFSC-identified future projects:

- Turtle bycatch reduction in scallop trawls and dredges (2010).
- Seabird bycatch reductions through completing gillnet seabird bycatch estimation analysis (2010).
- Finfish bycatch reduction in squid, herring, and multispecies trawl fisheries (2010–2015).
- Seabird bycatch reduction through bycatch estimation analysis for gear type(s) other than gillnets (2011–2013).

- Atlantic large whale take reduction in fisheries that entangle whales, through the development of gear modifications and other technologies to reduce takes (2011–2015).

Relative fishing power evaluation using net mensuration and fishers-collected gear and catch data

The SMAST Study Fleet is composed of offshore groundfish otter trawl vessels from New Bedford, Massachusetts. Vessels report total catch, environmental conditions, length frequency data and gear characteristics on the effort level. The project has incorporated technological advances with the use of gear mensuration equipment, digital motion compensating scales, and temperature-depth sensors. Gear dimensions were collected during normal fishing operations with NetMind mensuration equipment during study fleet trips when an SMAST technician is on board. Sensors are placed on the otter trawl doors, headrope, and the top wings of a net. A predictive relationship between door spread and gear attributes was developed using multiple linear regression. Area swept estimates were calculated for each tow using predicted door spread, and measures of tow speed, and tow duration. Catch data for the top 15 species in the database (which account for 98% of the total catch biomass) were divided by area swept for each trawl resulting in raw catch-per-unit-effort (kg/km^2) estimates. The next step will be to standardize the raw cpue for each species using a delta-lognormal generalized linear model and to estimate the effects of explanatory variables included in the database.

Contact: Groundfish Research Team (Steve Cadrin/Tony Wood/Sally Roman (sroman@umassd.edu)

Real-time yellowtail flounder bycatch avoidance research in George Bank scallop fishery

The SMAST's Marine Fisheries Field Research Group is developing a system that will facilitate avoidance of yellowtail flounder bycatch in the scallop fishery access area of the Nantucket Lightship Closed Area off Cape Cod, northeastern USA. The scallop harvest is constrained by a Total Allowable Catch of yellowtail flounder, which could result in early closure of the area and loss of economic yield. SMAST has partnered with the Virginia Institute of Marine Science (VIMS) to provide information to the scallop fleet on the distributions of scallops and yellowtail in the area in order to encourage yellowtail avoidance. Furthermore, SMAST has proposed a real-time bycatch avoidance system that utilizes e-mail communications during the access area fishery. Scallop vessel captains would send an e-mail to SMAST at the completion of every fishing day. The e-mails would provide a tow by tow record of yellowtail flounder bycatch to increase the spatial and temporal resolution of this information. SMAST would compile the information daily and produce maps of yellowtail flounder bycatch. SMAST would then send an e-mail back to the active fishing vessels once daily reporting "hot spot" areas of yellowtail flounder bycatch. The objective of this proposed system is to actively engage the fishing industry in bycatch avoidance through real-time data exchange.

Contact: Scallop Research Team Kevin Stokesbury (kstokesbury@umassd.edu)

Bycatch reduction in shrimp trawls

The topless shrimp trawl tested during 2005/2006 has been commercially used in the Gulf of Maine Pandalus shrimp fishery with markedly less bycatch of finfish species. Four more trawls will be built and used on a semi-commercial basis. A shrimp trawl

size and species sorting grid experiment has been carried out. The experiment compares a 9 mm and 11 mm size sorting grid, as well as comparing a rig with and without a size sorting grid. A modified Nordmøre grid was also tested to further reduce catch of finfish, and showed very positive result. A combination grid of size sorting and finfish reduction showed good results in increasing size of shrimp caught as well as reducing finfish species.

Contact: Conservation Engineering Research Team Pingguo He (phe@umassd.edu)

Species separation in groundfish trawls - planned work

A project testing the rope separator haddock trawl on offshore grounds (Georges Bank) with a larger vessel >90 feet has been funded with sea trials planned during autumn 2010 and spring 2011. A project to test a large mesh trawl for silver hake to reduce spiny dogfish has been funded with sea trials planned during the summer/autumn 2010 in southern New England. Another silver hake trawl project to modify the belly of the trawl to reduce flounder has been planned for autumn/winter 2010 in Gulf of Maine. In collaboration with Mike Pol of Massachusetts Division of Marine Fisheries, a project to test bycatch reduction devices for squid trawls to reduce scup, butterfish and winter flounder has been funded, with sea trials planned for autumn 2010. The preliminary design includes the raised footrope design and a sorting grid. The final design for sea trials will be decided through drop tests and flume tank tests.

Contact: Conservation Engineering Research Team Pingguo He (phe@umassd.edu)

Book: Behaviour of Marine Fisheries – Capture Processes and Conservation Challenges

This book, published by Wiley-Blackwell and edited by Pingguo He includes contributions from several scientists from the ICES/FAO FTFB Working Group. The book consists of thirteen chapters encompassing fish behaviour, fish capture processes, and contemporary conservation issues in marine capture fisheries.

Contact: Conservation Engineering Research Team Pingguo He (phe@umassd.edu)

Gulf of Maine Research Institute (GMRI), Portland, Maine

Contact: Steve Eayrs (steve@gmri.org)

Development of Selective, Fuel Efficient Trawl Net

Over a two-week period in 2009, a covered codend experiment tested the selectivity of four codends: a commercially used codend constructed from 6.5-inch diamond mesh netting and three experimental codends. The experimental codends were a 6.5-inch square-mesh codend, a 7.0-inch square-mesh codend, and a composite codend constructed from both 6.5-inch diamond and square-mesh netting. Catch data were collected from 79 one-hour tows. All codends retained between 22% - 35% of all animals that entered each codend. Selection curves indicated that the 6.5-inch square-mesh codend retained a substantially larger proportion of legal-sized American plaice than the other codends, although it also retained the largest proportion of 30 - 36 cm sublegal American plaice. The 6.5-inch diamond mesh codend retained the smallest proportion of legal-sized American plaice and also the smallest proportion of sublegal individuals measuring 24 - 36 cm. For each codend type, the selection curves for grey sole were essentially similar to that for American plaice with similar relative performance between codends; curves were also similar to a similar study in

2008. The curves from both datasets suggest that the 7.0-inch square-mesh codend may provide the best compromise between retaining legal-sized individuals while allowing the escape of sublegal individuals. The catch of non-commercial species was also evaluated, and the 7.0-inch square-mesh codend was also highly effective in reducing catches of these species, including dogfish, redfish, and snow crabs.

A contemporary assessment of the bycatch of regulated species and the Nordmore grate in the Northern Shrimp fishery

Participants in the Gulf of Maine northern shrimp trawl fishery (*Pandalus borealis*) have been required to use the Nordmøre grate since April 1992, with hopes of reducing bycatch of regulated groundfish species to 5% or less. Currently there have been few studies to quantify or describe this bycatch. Field sampling for this project occurred from January-March 2009 for a total of 36 days at sea and 128 hauls, aboard four vessels in four different locations. Preliminary results indicate that average regulated species (RS) bycatch for all boats was 1.6% of total catch weight. Over 75% of the hauls had RS bycatch of less than 2%, and RS bycatch exceeded the 5% target in only about 6% of hauls. All but one of the tows, which had RS bycatch of 17.3%, were below 8%. Bycatch in all locations was dominated by the American plaice flounder (dab), a red/white hake mix, and winter flounder (blackback). Orientation of the grid with escape opening facing up or down did not appear to have an effect on bycatch but greater sample size is needed to analyse this thoroughly. The bar spacing (1-inch) was thought to exclude small flounders that were seen in the catch, suggesting the fish are turning "on edge" to fit through the grate: this type of behaviour has been observed in response to ground cables and net sweeps.

Study on catch retention using a larger TED in summer flounder trawl fishery

Turtle excluder devices (TEDs) have been required in portions of the Mid-Atlantic summer flounder trawl fishery for almost two decades. Testing of a larger Flounder TED in the Mid-Atlantic Bight during normal commercial fishing operations off of New Jersey using an alternate haul method resulted in an overall 13.4% per cent reduction of summer flounder catch rates, but analysis did not show this to be a (statistically) significant loss – primarily because of large between-haul variability. The loss of summer flounder on a monthly basis was inversely associated with summer flounder catch volume, with lower catch rates (higher loss rates) seen in early summer, and higher catch rates (lower loss rates) seen in late summer. Length sampling revealed the larger Flounder TED reduced the catch of larger summer flounder with a 43% loss of "jumbo" summer flounder caught in the treatment tows. Flounder catch reduction recorded in this study with the larger Flounder TED was lower than comparable catch reduction rates reported with the standard Flounder TED in 2007. Further study utilizing camera gear would help gain insight into behavioural interactions with the larger grid.

Commercial Fishing Vessel Electronic Trip Reporting Pilot Study

The primary goal of this ongoing pilot study is to collaborate with fishing sectors and NMFS to test the feasibility of adopting electronic solutions for sector reporting requirements across a representative range of sector vessels in the northeast groundfish fleet. The pilot study is designed to test a range of electronic logbook products and the NEFSC's web-based data entry portal to identify obstacles to their use by captains and sector managers, as well as ensure their compatibility with NMFS's data collec-

tion systems. Currently 20 vessels across various sectors have been equipped with necessary hardware and software, with captains receiving training on data collection and reporting protocol.

University of Rhode Island Fisheries Center, Kingston, Rhode Island

Contact: Laura Skrobe (lskrobe@uri.edu), Kathleen Castro, Barbara Somers, and Christopher Parkins

Exploring Bycatch Reduction of Summer Winter, Yellowtail, and Windowpane Flounders Using the (12 inch) Drop Chain Trawl Net Design in the Small Mesh Fishery

The effectiveness of a 12 inch drop chain on the small mesh net (experimental trawl) to reduce the catches of summer flounder, winter flounder, yellowtail and windowpane flounders in the small mesh fisheries will be tested. The intent is to lift the opening of the net off the bottom which will allow summer flounder and other flatfish that are encountered to slide under the net without being retained. Adjustments to the sweep design were made during initial flume tank testing of the experimental net. Sea sampling will be conducted around Block Island Sound and Rhode Island Sound and consist of 12 fishing days starting in June 2010 with 4 days in each month using side-by-side vessels. Ultimately, success of this project would lead to the incorporation of the experimental trawl into the fishery management plan and successful continuation of profitable fisheries.

Reduction of Butterfish and Scup Bycatch in the Inshore Loligo Squid Fishery

An experimental trawl with an escape panel and funnel was tested compared to control net using side-by-side vessels on its ability to reduce the catches of butterfish and scup in the Loligo squid fishery in Southern New England. Testing of the model net was conducted in the flume tank at the Marine Institute of Memorial University in Newfoundland in August 2009; field testing was conducted in and around Block Island Sound and Rhode Island Sound in autumn 2009 and spring 2010. The change of bycatch between the control net and the experimental net will be evaluated. If these selective fishing practices yield the expected results, this gear would aid in the allowance for stock rebuilding of butterfish and scup while maintaining the *Loligo* squid harvest.

Fishery Independent Scup Survey of Eight Hard Bottom Areas in Southern New England Waters

This project is entering its seventh year of funding. It is designed to collect scup from hard bottom sites in Southern New England, which are un-sampled by current state and federal finfish trawl surveys. Two commercial vessels are conducting the fieldwork and the URI Fisheries Center is leading the data analysis and report preparation. Staff from the RI Department of Environmental Management Division of Fish and Wildlife (RIDEM DFW) and the Massachusetts Division of Marine Fisheries (MADMF) are collaborating on the project. The age distributions of the catch will be statistically compared to each of the other collection sites, to finfish trawl data collected by the National Marine Fisheries Service (NMFS) and the RIDEM DFW. Additionally, analysis will be conducted on all seven years of data.

Evaluation of Rhode Island fluke sector pilot program and implications for regional implementation

The overarching goal of this project is to leverage the RI fluke pilot program to provide stakeholders and policymakers with information on the likely effects of expanding sectors to the New England multispecies fishery. We will gather information on the economic, sociological, and biological performance of the RI program with the aim to facilitate fact-based constructive discussions about this management scheme. To meet this goal, the project has four objectives:

1) Examine the extent and the mechanisms through which sector vessels reduce bycatch and discarding, and how it compares with the non-sector vessels;

2) Characterize the fishing effort being applied by the sector and non-sector vessels in terms of choice of fishing areas, landing composition, and the timing of harvest and landing.

3) Examine the extent and the mechanisms by which sector fishers enhanced their profitability, as well as the market impacts of sector fishers on non-sector fishers;

4) Examine the attitudes and perceptions of sector and non-sector fishers relative to science and management issues that influence decisions and choices made by active fishers.

Consortium for Wildlife Bycatch Reduction

Contact: Tim Werner (New England Aquarium; twerner@neaq.org), Ken Baldwin (Center for Ocean Engineering, University of New Hampshire), Scott Kruas (New England Aquarium), Patrice McCarron (Maine Lobstermen's Association), Andy Read (Duke University Marine Lab), Rich Ruais (Blue Water Fishermen's Association)

The Consortium for Wildlife Bycatch Reduction is a partnership of fishers, wildlife biologists, and engineers. The Consortium supports collaborative research between scientists and the fishing industry to develop practical fishing techniques that reduce the bycatch of threatened non-target species. Projects supported by the Consortium come under three main categories: (1) Global exchange of bycatch reduction technology; (2) Understanding wildlife interactions in commercial fishing operations; and (3) Research and development of bycatch reduction methods. Current Consortium projects are described below.

Reverse engineering of baleen whale entanglements

Contact: Duke University; H. McKenna, Maine Lobstermen's Association; M. Moore, New England Aquarium; Provincetown Centre for Coastal Studies.

The Consortium is coordinating a forensic study of right and humpback whale entanglement events, which involves analyses of fishing gear retrieved from entangled whales and comparing them to the entanglement complexity and resulting scarring. The two objectives of the study are to identify the characteristics of fishing gear that cause severe and fatal entanglement risk to whales, and to provide a stronger scientific basis for evaluating the impact of existing, proposed, and future potential fishing methods to whales. One output of this project will be a computer model depicting whale entanglement scenarios that will also attempt to reverse engineer particular entanglement events.

Modelling right whale flipper-fishing line interactions

Contact: New England Aquarium; University of New Hampshire.

In 2008, the Consortium tested encounters between a full-size model of a right whale flipper and buoy lines of a five-trap trawl. The results indicated that the duration of the entanglement was slightly dependent upon the location of the strike along the leading edge of the flipper, and highly dependent upon the angle of the flipper relative to the longitudinal orientation of the whale. Analyzing entanglement duration according to where along the flipper edge ropes first made contact, there was a weak trend toward decreasing mean entanglement durations from 38.8 seconds near the body to a mean of 20 seconds at the outermost section of the flipper, but the differences were not statistically significant. However, the mean entanglement duration showed a strong decline from 61.6 seconds in the acute (angled forward) position to 20.9 seconds in the normal (right angle) position, to 11.9 seconds in the oblique (angled backwards) position. The results of this study indicated that there are rope or gear characteristics that potentially could facilitate more rapid release of the rope from the flipper under some typical fishing circumstances. In 2010, engineers at UNH will conduct trials with ropes of different diameters and bottom-to-surface tensions in order to simulate the variables inherent in the lobster fishing industry in different parts of the Gulf of Maine. Among the objectives are to see if ropes with more tension might lead to fewer entanglements.

Marine mammal colour vision and fishing gear avoidance

Contact: J. Fasik, Kean University

Dr Fasick is using molecular techniques in the first examination of the visual pigments from the North Atlantic right whale *(Eubalaena glacialis).* The objective of his study is to identify the wavelength(s) of light that will give right whales the highest level of contrast to their visual perception. The results of this research will be used to design a field study to evaluate the potential of visual deterrents to right whale-fishing rope conflicts.

Current best fishing practices for mitigating entanglement risk to whales from lobster gear

Contact: Maine Lobstermen's Association; New England Aquarium

Fishermen have a unique and essential perspective when evaluating options for modifying fishing gear or methods conceived to reduce bycatch. MLA is compiling a report on the range of gear configurations employed by lobstermen in the Gulf of Maine, and engaging these fishers in discussions about promising fishing methods that might lead to a lower frequency of serious whale entanglements. This project's aim is to identify current lobster fishing practices that may pose the least risk to whales while also identifying ideas for new methods or expanding the use of techniques considered more beneficial to reducing severe whale entanglements.

Evaluating "whale-safe" hooks in the southern Mid-Atlantic Bight pelagic longline fishery

Contact: Nova Southeastern University Oceanographic Center

Pelagic longliners based out of Wanchese, North Carolina are undertaking a study in 2010 with Dr Dave Kerstetter to evaluate the potential of a "whale safe" hook to maintain target catch levels (primarily tuna) while reducing interactions with pilot

whales. Experimental hooks were designed at a strength that should retain target catch while becoming straightened under the pull of a pilot whale's mouth. This trial is focused on reducing mortality to pilot whales in this fishery while avoiding the prospect of restrictive regulatory measures that could challenge its commercial viability.

Efficacy of electropositive metals to reduce shark bycatch in longline fisheries

Contact: Florida Atlantic University, New England Aquarium

This research is integrating behavioural and neurophysiological approaches to understand the mode of action of electropositive metals on the elasmobranch electrosensory system. Previous studies on electropositive metals were conducted by various investigators using different metals, variable study conditions, behavioural assays and species. This study is employing a standardized assay to test representatives of taxonomically diverse families that are encountered in commercial longline fisheries including hammerhead (Sphyrnidae), requiem (Carcharhinidae), and dogfish sharks (Squalidae) as well as stingrays (Dasyatidae). This study will help elucidate which groups/species the metals will most effectively repel, thus guiding field application for future research and actual longline fishing operations.

Bycatch Reduction Techniques Database (www.bycatch.org)

Contact: New England Aquarium

The Consortium maintains a searchable online database of global bycatch reduction techniques (*www.bycatch.org*). The database includes citations for bycatch studies with summaries of their main findings. The bycatch reduction techniques referred to in these studies are defined in an accompanying glossary. Users can conduct searches of these studies by year, gear type, reduction techniques, or non-target wildlife group. Where available, links to the complete studies and contact information for authors are included. New additions to the database are made voluntarily by registered users.

New England Aquarium, Marine Conservation Engineering Program, Boston, Massachusetts

Contact: Tim Werner (twerner@neaq.org)

The New England Aquarium is supporting field tests of two types of gillnets produced with innovative materials, one manufactured with barium sulphate and another consisting of a stiff nylon. The nets are relatively inexpensive and in previous field trials showed significant reduction in the bycatch of small cetaceans and seabirds with only a small reduction in target catch levels. A field trial in Argentina evaluating the efficacy of experimental nets for reducing bycatch of franciscana (*Pontoporia blainvillei*) in an artisanal croaker gillnet fishery is nearing completion. Preliminary results indicate that the three nets used in the experiment performed equally well in catching commercial target fish species. Although the two experimental nets caught fewer franciscana, preliminary analyses indicate the differences are not significant. A second field trial is being implemented in São Paulo State, Brazil, and will evaluate the potential bycatch mitigation effect of experimental nets not only for franciscana but also sea turtles (greens, primarily). Local gillnet fishers target bottom-dwelling species (mainly sciaenids), pelagic bony (scombrids) fish, and sometimes also sharks (carcharhinids). This trial is being led by Dr Eduardo Secchi of the Federal University of Rio Grande with Dr Carolina Bertozzi.

New England Aquarium, Edgerton Research Laboratory, Boston, Massachusetts and University of New England, Marine Science Center, Biddeford, Maine

Contact: John Mandelman (jmandelman@neaq.org), James Sulikowski (UNE), Angela Cicia (UNE)

Immediate and delayed mortality of skates subsequent to otter trawl and sink-gillnet capture

Species from the family Rajidae are routinely discarded during commercial fishing operations in the Northwest Atlantic Ocean due to regulatory and market factors. This ongoing study is investigating the post-capture/handling viability and delayed (post-release) mortality of four rajids indigenous to the Gulf of Maine (USA) - *Amblyraja radiata*; *Leucoraja ocellata*; *Malacoraja senta*; and *Leucoraja erinacea* - subsequent to otter trawl and sink-gillnet capture during normal commercial fishing activities. Thus far, ~800 skates have been monitored for delayed mortality in the study, with extensive work slated for the remainder of 2010. Analysis is ongoing and the work will be presented at multiple meetings this summer/fall. There is a paucity of data addressing the condition and mortality of skates caught by commercial fishing activities, and results from this study will aid in the management and stock assessments for these species.

Investigating the acute physiological effects of air exposure and the implications on discard survival in skates from the western Gulf of Maine

Skates are routinely discarded as bycatch, and these capture events involve a variety of physiological stressors that may impact survivability. As part of the larger bycatch mortality study on skates, we are examining (in the laboratory) the physiological changes and delayed mortality associated with graded periods of air exposure - an obligate repercussion of "deck-time" during sorting of the catch – by species. Data will help reveal the comparative resiliencies to deck-time among these species, which will further aid management.

NOAA Fisheries, Atlantic Highly Migratory Species, Silver Spring, Maryland

More info:
http://www.nmfs.noaa.gov/by_catch/docs/report_to_congress_brep_2010.pdf
Future work:

- Billfish, bluefin tuna, and sea turtle bycatch reduction in Gulf of Mexico longline fisheries through investigation and characterization of green-stick gear (2010–2012).
- Buoy gear bycatch reduction in the swordfish handgear fishery through investigation and characterization of bycatch in that fishery (2010).
- Sea turtle bycatch reduction in Atlantic shallow-set longline using techniques developed in experiments in the Pacific Ocean (2010–2013).
- HMS rod and reel bycatch reduction through investigation and characterization of bycatch in that fishery (2012–2015).

NOAA Fisheries, Southeast Fisheries Science Center

More info:

http://www.nmfs.noaa.gov/by_catch/docs/report_to_congress_brep_2010.pdf

Shrimp Trawl Bycatch Reduction

The Composite-Panel BRD, a design provisionally certified for use in the Gulf of Mexico and the US South Atlantic shrimp trawl fisheries, has shown an overall finfish bycatch reduction rate of 25.3% in the Gulf of Mexico shrimp fishery. In an attempt to increase the finfish reduction rate associated with the Composite-Panel BRD, a fisheries-dependent certification test was conducted with a combination of the Composite–Panel BRD and a Square Mesh Panel BRD. A total of 102 tows have been completed. The observed finfish reduction rate with this BRD combination is 36% by weight, with a shrimp reduction rate of 4%. The reduction in finfish observed during the experiment exceeds the minimum BRD certification criteria of 30% reduction in total finfish weight. Additional testing is being conducted aboard commercial vessels to evaluate the effect of the square mesh panel size and placement and codend construction materials on the performance of this BRD combination.

Gulf of Mexico Pelagic Longline Bluefin Tuna Bycatch Mitigation (Pilot)

Spawning bluefin tuna, much larger than yellowfin tuna, may be capable of straightening some types of hooks used in the yellowfin tuna fishery. During year one of the research (2007), fishery-independent experiments were conducted to collect data on the relative force exerted by bluefin and yellowfin tuna when captured on pelagic longline gear. Treatments of three different breaking strengths of monofilament leader (140, 200, and 250 lbs.) were tested to determine which would effectively release bluefin tuna yet retain yellowfin tuna. Based on the data collected, 140-lb. and 200-lb. monofilament leaders were found to be capable of releasing bluefin tuna of the sizes of fish captured. In year two of the project (2008), a fishery-dependant experiment was initiated to investigate the potential of a newly designed hook as a mitigation measure for reducing bluefin tuna capture on pelagic longlines. The experimental hook retains the dimensions of a 16/0 hook but has less tensile strength, causing it to bend or straighten at loads that would not bend a conventional 16/0 hook. Vessels fished with industry standard gear utilizing the experimental hook on every other leader. Cumulatively for the period 2008 to 2009, 5 vessels have made 20 trips. One hundred ninety-seven sets have been conducted with a total of 123,872 hooks set. A total of 20 bluefin tuna have been caught, of which 16 were caught on the control hook for a 75% observed reduction rate. A total of 1,573 yellowfin tuna have been caught. The observed reduction in yellowfin by count is 5.6% with the experimental hook. Based on these results, NMFS proposes to continue this research in 2010 in order to improve the statistical confidence of the experiment results.

Development of improved TED designs for the flynet fishery

The TED developed for use in the flynet fishery was constructed of aluminium flat bar with a centre section composed of stainless steel cable, which allows it to flex. Target catch loss for this TED was 6.7% (95%CI -28.0% to 14.6%). In addition, unwanted catch of spiny dogfish (*Squalus acanthias*) and clearnose skates (*Raja eglanteria*) were reduced by 40% and 63%, respectively. During usability testing aboard commercial vessels, handling of the TED was relatively easy with a small learning curve required to prevent gear damage. The TED was also tested for turtle exclusion utiliz-

ing the standard small turtle test required for all TEDs certified for use in US fisheries. The flynet TED passed in a top-opening configuration, excluding 24 out of 25 turtles. The TED will undergo additional usability testing prior to implementation into the fishery.

A Pilot Study to Assess Catch Rates of Shrimp and Finfish Catch and Bycatch using TEDs with Reduced Bar Spacing

The project is designed to conduct comparison tows between a TED with two-inch deflector bar spacing and a traditional TED with four-inch bar spacing as a means of assessing differences in bycatch and shrimp catch rates. Although results from this study are not yet available, the evaluation of TEDs with reduced bar spacing as a means of improving bycatch reduction is being pursued by other fisheries researchers including those at the Georgia Marine Extension Service. International studies have shown as much as a 30% reduction in finfish bycatch with two inch TEDs when compared to four-inch TEDs, with no difference in catches of shrimp.

Evaluation of Hook Guards, Larger Circle Hooks, and Non-offset Hooks in Preventing Interactions with Sea Turtles in the Gulf of Mexico Bottom Longline Fishery

Industry groups have proposed to test several gear modifications that have potential in reducing sea turtle takes in reef fish bottom longline gear. Divers observed that the 1/8 inch (3 mm) stainless steel mainline laid flat on the bottom and became buried in the sand/shell substrata in a relatively short period of time. A comparison of the fishing configuration of short vs. longer gangions (4.5 ft [1.3 m] vs. 12 ft [3.6 m]) showed little difference in the position of the bait on the bottom relative to the mainline. Only four of the eight hook guard designs evaluated performed as designed, i.e. separating from the hook/bait once it contacted bottom. Factors affecting hook guard performance included buoyancy of the guard and size of the hook in relation to the guard (smaller hooks may become wedged in the guard, thus preventing the guard from separating from the bait at depth). Additional work is needed to fully assess the feasibility of hook guards as a mitigation measure for the fishery, including in-situ observations of guards and gangions at typical fishing depths using tethered cameras or remotely operated vehicles.

Future work

- Turtle bycatch reduction in the Gulf of Mexico bottom longline reef fish fishery (2010–2012).
- Bluefin tuna bycatch reduction in the Gulf of Mexico yellowfin tuna fishery (2010–2012).
- Seabird bycatch reduction through enhanced observer coverage to assess potential protected species interactions with fisheries in the Atlantic (2010–2015).
- Turtle bycatch reduction in non-shrimp trawls fisheries (Atlantic flynet fishery, Atlantic whelk trawl fishery; 2010–2015).
- Turtle excluder device and bycatch reduction device refinement in shrimp trawl fishery (2010–2015).
- Turtle bycatch reduction in various Atlantic and Gulf of Mexico gillnet fisheries (2010–2015).

- Turtle entanglement/bycatch reduction through development of weak links for the vertical lines used for buoys in a variety of pot fisheries (2010–2015).
- Shrimp bycatch reduction through testing of Australian "hopper" gear for improved survivability of shrimp bycatch (2011–2015).

NOAA Fisheries, Southwest Region and Southwest Fisheries Science Center, La Jolla, California

Collaborative Research on Reducing Post-Release Mortality for Common Thresher Sharks Captured in the Southern California Recreational Fishery

The primary techniques employed in the recreational thresher shark fishery entail trolling heavy baited lures with large J-type hooks through well-known spawning and feeding aggregation areas (e.g. canyon heads and nearshore banks) in the Southern California Bight. Because thresher sharks utilize their elongate upper caudal fin to stun live prey before it is consumed, >90% of sharks are foul-hooked and subsequently hauled in backwards during the fight, potentially increasing post-release mortality rates. Field trials were primarily based on replacing the J-hooks currently used in the fishery with circle hooks. Six of the ten individuals caught using these alternative techniques were hooked in the mouth. However, the use of circle hooks did not eliminate the incidence of foul-hooking. Although the initial gear trials indicated that the use of circle hooks may reduce the number of foul-hooked sharks captured in the recreational fishery, additional field trials are necessary to determine the effectiveness of this gear modification.

Future Work:

- Shark bycatch and bycatch mortality reduction in drift gillnet and pelagic longline fisheries (2010–2011).
- Turtle bycatch reduction through development of predictive models of turtle distribution (2010–2011).
- Seabird bycatch reduction through enhanced collection of seabird distribution and abundance data on cetacean and ecosystem assessment cruises, action at international regional fishery management organizations, and information and outreach to fishery participants (2010–2011).
- Pinnipeds bycatch reduction through the transmission of sound to deter the animals from active fishing vessels (2010–2011).
- Evaluation of gear modifications to prevent marine mammal depredation in the California halibut trawl fishery in Southern California (2010–2011).
- Shark bycatch mortality reduction in recreational catch-and-release fishery (2010–2012).
- Ocean sunfish (*Mola mola*) bycatch reduction in drift gillnet fishery (2011–2013).

Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon

Evaluating the effect on eulachon bycatch (*Thaleichthys pacificus*) of reduced bar spacing in a rigid-grate BRD in the ocean shrimp (*Pandalus jordani*) trawl fishery

Contact: Bob Hannah (bob.w.hannah@state.or.us) and Steve Jones

We compared shrimp catch and bycatch between two rigid-grate BRDs with 0.7-inch and 1.25-inch vertical bar spacing, with an emphasis on reduction of eulachon (*Thaleichthys pacificus*) bycatch. Closer bar spacing reduced overall bycatch, especially juvenile hake, juvenile rockfish and small flatfish, while maintaining shrimp catch rates. Unfortunately, eulachon abundance was too low and variable in 2009 to measure reductions in eulachon bycatch. This work will continue in 2010, along with tests of changes in footrope configuration on eulachon entrainment.

Estimating discard mortality of Pacific rockfishes (*Sebastes*) in the recreational hook and line fishery

Contact: Bob Hannah (bob.w.hannah@state.or.us) and Polly Rankin

After several years of testing of different cage designs for the purpose of holding individual Pacific rockfishes for discard mortality studies, a cage design that has virtually no adverse effects on rockfish held 48 hours on the seabed in the open ocean has been developed. The cage is constructed of a plastic pickle barrel with a smooth interior to reduce abrasion, screened against predatory amphipods, with a dual anchor system to prevent pulling from surface swell and against movement or rolling due to surge. Field studies using this very "fish friendly" caging system to estimate discard mortality of various rockfish species after hook and line capture, as a function of depth of capture, were initiated in 2009 and will continue in 2010.

NOAA Fisheries, Northwest Fisheries Science Center, Seattle, Washington

More info:

http://www.nmfs.noaa.gov/by_catch/docs/report_to_congress_brep_2010.pdf

Flexible Sorting Grid for Salmon and Rockfish in the Pacific Whiting Fishery

An open escape window bycatch reduction device (BRD) to reduce endangered Chinook salmon and rockfish (genus *Sebastes*) bycatch (e.g. darkblotched, canary, and widow) in the Pacific whiting fishery was tested. This BRD design consists of two mesh panels, positioned near the codend of a midwater trawl, which direct actively swimming fish toward an open escape window on the top and upper sides of the net. This BRD is designed so that fish displaying strong swimming abilities (e.g. salmonids and rockfishes) can escape through the open windows, whereas fish exhibiting weak swimming abilities (e.g. Pacific whiting) will pass into the codend. A five-day research cruise in September 2009 aboard a trawler recorded chinook salmon behaviour within the BRD using an open codend and an autonomous video camera. Eight salmon were observed, with five salmon (> 62%) escaping via the BRD. Planning is currently underway to conduct further development and testing of the open escape window BRD concept in the Pacific whiting midwater trawl fishery as well as other west coast trawl fisheries.

Behavioural Differences in Distance of Roundfish to Footrope Measured using DIDSON

This collaboration with the gear research group at the Oregon Department of Fish and Wildlife (ODFW) is focused on observations of fish behaviour in the vicinity of the footrope of a bycatch-reducing selective flatfish trawl, using dual-frequency identification sonar (DIDSON) ultrasonic camera. The DIDSON was used to examine diel behaviour differences in roundfish along a 12-meter section of the footrope on the starboard wing of the flatfish trawl. During FY09, data extraction was completed for individual fish tracks from all of the archived DIDSON data collected in 2006 and 2007. Movements of individual roundfish were tracked, providing a continuous measurement of distance from the footrope. Analysis of fish tracks revealed that during the day, roundfish remained farther from the footrope, maintained a relatively constant distance, and showed less variation in direction. At night, fish approached the footrope at a sharper angle and displayed a more abrupt change in speed and direction. These behavioural differences suggest that herding efficiency and gear selectivity is different between day and night fishing.

Bycatch Avoidance Using Seabed Classification

A pilot project in the vicinity of Morro Bay, California to integrate seabed classification using Quester Tangent QTC VIEW and commercial fishing activities was continued. This project will consider questions such as: can high-quality data be collected during normal fishing operations to inform NMFS about bottom type with minimal impact on fishing operations; and will patterns in bycatch relate to specific seabed classifications?

Future Work:

- West coast groundfish bycatch reduction by improving the performance of already proven bycatch reduction gear types, e.g. selective flatfish trawl to reduce rockfish bycatch in flatfish fishery (2010).
- Seabird bycatch reduction through continuation of Seabird Bycatch Research project to reduce potential fisheries interactions with short-tailed albatross and other seabird species (2010–2012).
- Endangered Species Act-listed salmon bycatch reduction, as well as rockfish bycatch reduction, through refinement and implementation of flexible sorting grids in the west coast Pacific hake fishery (2010–2015).
- Habitat impact reduction through testing the linkage between observer derived estimates of bycatch with co-registered information on type of habitat swept (e.g. information derived from fishing vessel on board acoustic seabed classification systems; 2010–2015).
- Seabird bycatch reduction in Alaska and Northwest longline fisheries by providing free streamer lines and cost-sharing on integrated weight lines (2010–2015).

NOAA Fisheries, Alaska Fisheries Science Center, Seattle, Washington

More info:

http://www.nmfs.noaa.gov/by_catch/docs/report_to_congress_brep_2010.pdf

Salmon Excluders

Improved excluder devices using a panel that blocks escape portals during regular towing and opens them during scheduled periods of slower towing ("flapper excluders") to avoid clogging of the excluders were tested in two cruises. Many of these devices are currently being used in the fishery, but the most recent version provided by a major net manufacturer had not been tested for effectiveness. A September 2009 test used that version, which places the excluder just ahead of the codend, further back in the net than previous excluders. Salmon escape measurements for the flapper-style excluder indicated substantially reduced exclusion rates when escape portals were only available during slow-down events. We identified ways to achieve continuous availability by modifying the location and weighting of mesh panels.

Reduce trawl damage to seabed invertebrates

Work in this area in 2009 focused on providing research results to managers and other stakeholders as they decide whether to require trawl sweep modifications for the Bering Sea flatfish fisheries. We also conducted research to explore variations of the sweep modifications that would help fishers transition to their use. A nine-day research cruise in June tested whether smaller-diameter sweep cables, which would alleviate handling problems associated with the modifications, would still effectively herd flatfish.

Crab mortality rates after trawl encounters

Crabs were recaptured after passing under the central and side sections of a trawl footrope, as well as after contacting the sweeps ahead of the trawl. Crabs were also assessed after capture by a similar net fished ahead of the trawl, to estimate and account for the effect of capture and handling. Finally, we evaluated the effectiveness of modifications to sweeps and footrope that were expected to reduce crab mortality. More than 3,700 crabs from 73 trawl hauls were assessed for reflex impairments, while more than 738 were assessed then held in on-board tanks to establish the association between these impairments and the probability of mortality. Estimates of crab mortality rates after trawl encounters were generated for all major Bering Sea crab species. Sweep modification reduced all of those rates.

Future Work:

- Salmon bycatch reduction in Alaska pollock fisheries through trawl modifications (2010–2012).
- Pacific halibut bycatch reduction in Gulf of Alaska and Eastern Bering Sea groundfish (cod, flatfish, pollock) trawl and longline fisheries through development of fisheries-specific bycatch reduction devices (2010–2015).
- Crab bycatch reduction in groundfish fisheries through development of gear modifications (although trawl bycatch is a higher volume issue, bycatch of blue king crab in cod pots (baited traps) has a higher priority due to concern over potential overfishing of that species; 2010–2015).

- Seafloor habitat and Essential Fish Habitat impact reduction by modifying trawls and trawling methods (2010–2015).
- Seabird bycatch reduction in Alaska trawl fisheries by further developing effective seabird mitigation gear, enhancing bycatch monitoring, exploring the role of vessel attraction and providing free seabird bycatch reduction gear (2010–2015).
- Seabird bycatch reduction in Alaska and Northwest longline fisheries by providing free streamer lines and cost-sharing on integrated weight lines (2010–2015).
- Reduction of unobserved crab mortality due to trawl encounters through development and implementation of modified trawl groundgear (2010–2015).
- Development of a more efficient method for identifying incidentally caught Pacific halibut that are live-release candidates (i.e. high survival rate), and development of methods consistent with observer program protocols for sorting, accounting, and discarding halibut rapidly (2010 - 2015).

NOAA Fisheries, Pacific Islands Region and Pacific Islands Fisheries Science Center, Honolulu, Hawaii

More info:

http://www.nmfs.noaa.gov/by_catch/docs/report_to_congress_brep_2010.pdf

The Effects of Neodymium/Praseodymium (NdPr) Alloys on Shark Bycatch

We conducted fishing experiments with bottom-set longline gear targeting juvenile scalloped hammerhead sharks (*Sphyrna lewini*). Bottom-set longline gear contained branchlines that alternated between control 45g lead weights and 45g Nd-Pr weights. Results from 19 bottom longlines yielded a total of 59 scalloped hammerhead sharks, with 18 sharks caught on hooks with Nd-Pr metal weights and 41 sharks caught on hooks with control lead weights. The mean catch rate of control branchlines was 0.019 cpue (sharks/hook-hour) vs. 0.008 cpue on branchlines with NdPr metal, which represents a significant 58% decrease in catch rate. We also tested the effects of Nd/Pr on blue and mako shark bycatch off Southern California. Longline trials were composed of 200 branchlines in which branchlines with lead weight were alternated with branchlines with Nd/Pr metal weight. The number of floats was adjusted so that there were four branchlines between floats. A total of 25 longlines were set. The catch was composed of primarily mako sharks (*Isurus oxyrinchus*, n=117 caught) and blue sharks (*Prionace glauca*, n=37 caught). Analysis of catch data are ongoing, though initial analysis indicates no difference in the catch rates of blue and mako sharks between control branchlines with and without Nd/Pr metals.

Use of Photoluminescent Technology to Reduce Incidental Capture of Sea Turtles in Gillnet Fisheries

Experiments using gillnets illuminated by common chemical lightsticks in Baja California Sur, Mexico showed a 60% reduction in green sea turtle catch between gillnets with six-inch green chemical lightsticks placed every five meters, and control nets with non-activated lightsticks placed every five meters.. In six paired trials, illuminated nets had lower green sea turtle catch per unit of effort (cpue).

Combined with findings in 2008, these results provide compelling evidence that illuminating gillnets allows sea turtles to avoid being entangled and therefore can help in the reduction of their bycatch.

Future work:

- False killer whale take reduction in the Hawaii-based pelagic longline fishery through evaluation of circle hook effects (2010).
- Seabird bycatch reduction and longline fishers protection by developing and refining safe-lead weights and side-setting (2010).
- Shark bycatch reduction in the Hawaii-based pelagic longline fishery through continued testing of chemical (electropositive metals) deterrents (2010–2011).
- Marlin bycatch reduction in longline fisheries targeting tuna by continuing to develop operational alterations (depth, time, season, area) in the fleet (2010–2011).
- Evaluation of blue marlin post-release mortality in Pacific longline fisheries (2010–2011).
- Development of a California sea lion bycatch reduction strategy based on visual cues (2010–2011).
- Turtle bycatch reduction through development of measures to reduce interactions in gillnet fisheries (2010–2015).
- Turtle bycatch reduction through continued operation and analysis of "TurtleWatch," which provides fishing area advisory charts indicating turtle avoidance areas to Hawaii longliners (2010–2015).
- International sea turtle, shark, and gamefish bycatch reduction through testing and promoting longline bycatch mitigation methodologies including: (1) continued testing of circle hooks to reduce sea turtle bycatch and maintain target catch; (2) continued testing of stiffer lines to reduce turtle entanglements in longlines; (3) testing chemical methods of reducing shark bycatch (now under domestic development); and (4) testing of operational alterations to reduce marlin catches (2010–2015).
- Seabird bycatch reduction in longline fisheries by providing free safe-lead gear and cost-sharing for side-setting vessel conversions (2010–2015).

20 New Business

20.1 Date and Venue for 2011 WGFTFB Meeting

The **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chair: Mike Pol*, USA) will meet in Reykjavik, Island, from 9–13 May 2011.

20.2 Proposals for 2011 ASC Theme Sessions

Proposals for the 2011 ICES ASC were discussed but due to time constraints no decision was made. It was agreed WGFTFB would work by correspondence to formulate proposals before the 2010 ASC.

20.3 JFTAB

WGFTFB recommends a joint WGFAST/WGFTFB session is scheduled for the 2011 WGFTFB and WGFAST meetings to be held in Iceland. A topic has been suggested by WGFAST to explore how multiple technologies and methods either improve or complicate our understanding of what is actually out there, numerically, as well as ecologically and behaviourally. Questions include: can we decrease uncertainty with multiple techniques; is it cost-effective; does the promise of multiple technologies allow us to increase our knowledge to go beyond "simple" abundance estimates towards more accurate prediction of what those counted organisms will do, where they will go, and how they will react to natural and anthropogenic forces. Emma Jones, Julia Parish and or Alex De Robertis are proposed as co-chairs. This was discussed by WGFTFB and while some concerns were raised as to the relevance of this ToR, it was agreed to work with the co-chairs and WGFAST to develop this further.

20.4 ICES and other symposia

NOAA will host a three day conference on energy use in fisheries: improving efficiency and technological innovations from a global perspective. This conference is scheduled for 14–17 November 2010 in Seattle.

NOAA and the UN are planning an international marine debris conference for 20–25 March 2011 in Hawaii. This conference aims to bring together international marine debris researchers, natural resource managers, policy-makers, industry representatives and the nongovernmental community. This conference will highlight research advances, allow sharing of strategies and best practices to asses, reduce, and prevent the impacts of marine debris and provide an opportunity for the development of specific bilateral or multi country strategies. This would be an opportunity for FTFB members to present current information on abandoned, lost or otherwise discarded fishing gear and its impacts on marine resources.

A Russian conference on "FISH BEHAVIOUR" with foreign partners will be hosted by the Institute for Biology of Inland Waters RAS (IBIW RAS), situated in Borok, Nekouz, Yaroslavl region, Russia. The Conference is scheduled to be held in 9–11 November, 2010. The organizing committee intends to publish submitted presentations in the book of the Conference proceedings before the meeting. The application form should be sent by 1 July 2010 by e-mail: fishbehav2010@ibiw.yaroslavl.ru and lapshin@vniro.ru . The participants will also have the opportunity to receive current information about the Conference at the Site of the Institute for Biology of Inland Waters in the "Conference" section of http://www.ibiw.ru

20.5 Election of new chair

Michael Pol (US) was unanimously nominated by the membership of WGFTFB for the position of chair from 2011.

20.6 Any Other Business

The members of WGFTFB wish to record the contribution made to fisheries science made by Van Holliday, Ollie Hagstrom and Rolf Steinberg who all died in 2010.

Annex 1: List of participants

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Annex 2: Agenda

31 May 2010

10:00 – 10:30 Registration

10:30 – 11:00 Opening Address, Housekeeping Issues and Meeting Arrangements (Chair)

11:00 – 12:00 ICES Requests (Chair)

12:00 – 13:00 FAO Briefing (Frank Chopin)

13:00 – 14:00 Lunch

14:00 – 14:30 FAO Briefing (Frank Chopin)

14:30 – 14:40 Introduction to Open Session

14:40 – 15:00 Selection of *Nephrops* based on the FISHSELECT methodology Rikki Frandsen (DTU-Aqua)

15:00 – 15:30 Coffee Break

15:30 – 15:50 Sea trials for 8 trawl selectivity devices in the mixed hake-*Nephrops* fishery of the Bay of Biscay – Sonia Méhault (Ifremer)

15:50 – 16:50 ICES Structure and report from SSGESST (Bill Karp)

1 June 2010

09:00 – 09:10 Housekeeping

09:10 – 09:30 The use of Social Marketing to reduce Discarding – Andy Revill (Cefas)

09:30 – 09:50 Discarding in *Nephrops* trawl fisheries in Iceland – Haraldur Einarsson (IMR)

09:50 – 10:10 Scottish cod trials – Barry O'Neill and Rob Kynoch (FRS)

10:10 – 10:40 Irish Experiences with the Swedish Grid – Dominic Rihan (BIM)

10:40 – 11:00 Fish Behaviour and Analytical Techniques Determining of catchability coefficient for survey gillnets – Oleg Laphsin (VNIRO)

11:00 – 11:30 Coffee Break

11:30 – 11:50 Mortality rates of crabs passing trawl sweeps and footropes without capture and effectiveness of sweep modifications to reduce such mortalities – Craig Rose (NOAA)

11:50 – 12:10 The CatchMeter: video monitoring and real-time species and length analysis of fish in a trawl – Shale Rosen (Scantrol/IMR)

12:10 – 12:30 Highlights from Energy efficiency symposium in Vigo – Antonello Sala (ISMAR-CNR)

12:30 – 13:00 Poster presentations and sum up of Open session

13:00 – 14:00 Lunch

14:00 – 14:15 Report from WKPULSE (Bob van Marlen)

14:15 – 14:30 Report from SGTCOD (Bent Hermann/Waldmar Moderhak)

14:30 – 14:45 Report from SGEM

14:45 – 15:00 Discussion on Gillnet manual (Andy Revill)

15:00 – 15:30 Coffee Break

15:30 – 16:00 ToR b Seine Net Fisheries

16:00 – 16:30 ToR c Gear Monitoring

16:30 – 17:00 ToR d Innovation in Fisheries

17:00 – 17:30 ToR e WGECO/FTFB Framework

2 June

09:00 – 18:00 Topic Group Meetings

Coffee breaks and Lunch Breaks – decided by ToR chairs

3 June

09:00 – 16:00 Topic Group Meetings

Coffee breaks and Lunch Breaks – decided by ToR chairs

16:00 – 17:00 Future Structure of WGFTFB Meeting (Chair/Bill Karp)

4 June

09:00 – 10:30 Topic Group Meetings

10:30 – 11:00 Coffee Break

11:00 – 11:30 Presentation of report, conclusions and recommendations on Seine Net Fisheries

11:30 – 12:00 Presentation of report, conclusions and recommendations on Gear Monitoring

12:00 – 12:30 Presentation of report, conclusions and recommendations on Innovation

12:30 – 13:00 Presentation of report, conclusions and recommendations on Framework

13:00 – 14:00 Lunch

14:00 – 14:30 Discussion on ToR s 2011 including JFTAB (Chair)

14:30 – 15:00 Suggestions for ASC theme sessions 2011 (Chair)

15:00- 15:15 Election of New Chair (Chair)

15:15 -15:30 Date and venue for WGFTFB 2011 meeting (Chair)

15:30 – 15:45 AOB and concluding remarks (Chair)

Meeting Close

Annex 3: Recommendations

The following table summarizes the main recommendations arising from the WGFTFB and identifies suggested responsibilities for action.

	RECOMMENDATION	FOR FOLLOW UP BY:
1.	WGFTFB recommended that a timetable for provision of this information to the Assessment Working Groups be drawn up with ACOM and the assessment chairs that better reflects the timing of the individual working groups and the assessment process. WGFTFB further recommends that ACOM consider whether this information would be better collated at the Benchmark Workshops.	SCICOM/ACOM/WGCHAIRS
2.	Given the resurgence of seining as a fishing method in some countries and the technology creep noted, WGFTFB recommends further assessment to substantiate the environmental friendliness of seining.	WGFTFB/WGECO to note
3.	WGFTFB recommends an ICES workshop be held to review the results of selectivity experiments with seine net gear and assess methodology for measuring the selectivity of seine nets, which has proven problematic in the past.	SCICOM/WGFTFB
4.	WGFTFB recommend that this Topic Group meet again next year and extend the table of innovation projects with more information from other countries as well as updating project outcomes.	SCICOM/WGFTFB
5.	WGFTFB recommend that gear technologists carrying out research with gear measures designed to reduce bycatch and/or discarding should be encouraged to collect information on as many species (both commercial and non-commercial) as possible to allow more information and ultimate analysis of whether such GBTM can deliver positive benefits for the stocks of these species.	WGFTFB/WGISUR
6.	WGFTFB recommend that a Study Group on Electrical Fishing (SGEF) be established to review all the positive and negative ecosystem effects of using electrical stimuli.	SCICOM/WGFTFB WGECO/WGCRAN to note

Annex 4: WGFTFB terms of reference for the next meeting

The **Working Group on Fishing Technology and Fish Behaviour (**WGFTFB) chaired by Mike Pol*, US will meet in Reykjavik, Iceland from 9–13 May 2010 to address the following ToRs:

a) Incorporation of Fishing Technology Issues/Expertise into Management Advice. Based on the questionnaire exercise carried out since 2005/2006.

b) A WGFTFB topic group of experts will be formed in 2010 with the following terms of reference:

   i) Create an inventory of gear specifications (such as mesh size, trawl design, trawl orientation) used in harvesting redfish in member countries

   ii) Describe and synthesize research carried on size selectivity with various mesh sizes and configurations and investigate possible technical measures that could reduce the loss of redfish at the surface due to their developed buoyancy

   iii) Collect morphometric information necessary to predict size selectivity

   iv) Examine habitat use, especially water depth and water columns, by major commercial redfish species and application of the information for selective capture by trawls

c) A WGFTFB topic group of experts formed in 2009 will meet in 2010 to continue to address the following ToRs:

   i) Review available selectivity and catch comparison data from small and larger vessels

   ii) Review gear and operational parameters

   iii) Identify likely causes of differences in selectivity and investigate whether they are real

d) A WGFTFB topic group of experts will be formed in 2010 will meet in 2011 to continue to address the issue of Innovation in fishing gear technology and the success of collaboration between fishers and scientists with the following terms of reference:

   i) Review current technological developments and initiatives in gear technology and give examples of successful developments both in the EU and in other countries globally.

   ii) Discuss the contributions of fishers and scientists in the process of collaboration and identify conditions allowing rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects.

WGFTFB will report by 14 June 2011 (via SSGESST) for the attention of SCICOM.

Supporting Information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a

	very high priority.
Scientific justification and relation to action plan	Action Item 3.16, 3.17, 3.18, 5.8, 5.11, 5.16, 6.3 (a) Action Item 3.2, 3.13, 4.11.3, 4.13, 5.11 (b) Action Item 3.16, 3.18, 4.13, 5.8, 5.12 (c) Action Item 3.2, 3.5, 3.16,3.17,4.13, 5.8 (d) Term of Reference a) Fisheries management bodies are often dependant on catch per unit of effort for stock assessment purposes and fishery/fleet based advice. Identification and use of gear parameters that effect fishing efficiency will most likely improve the use of commercial catches for stock assessment purposes. WGFTFB has the expertise to identify such parameters and will work intersessionally, reviewing existing initiatives e.g. EC data collection regulation and provide a list for consideration during the 2010 WGFTFB meeting. The information collated by the WGFTFB has been well received by ICES assessment and other Expert Groups. It is intended to continue with the collation of this information but further developments are needed. WGFTFB has recommended a number of changes to improve the utility and simplicity of this work. The next questionnaire will be based on the emergent issues identified in this report, and focused on 2009/2010. Feedback on the content and value of this years report will be sought from the Assessment working groups and through WGCHAIRS and will be used to improve the survey in 2010. If possible, the EC should be asked to provide up to date information on recent TCM regulations. These will be included in the survey with a request to detail likely outcomes from these measures. Term of Reference b) Redfish are primarily harvested by trawls – either pelagic or bottom trawls. Due to their relative small sizes and their distribution in vertical columns, they offer a both opportunity and challenge to sustainable harvesting. In light of a NAFO request for more information on redfish harvesting, trawl codend selectivity, as well as challenges in under-harvesting of redfish resources in Northeast US. Term of Reference c) It is often argued by the fishing industry that the selectivity of smaller, low horsepower vessels differs from that of the larger vessels and therefore should subject to different management measures and in particular technical conservation measures e.g. codend mesh size, size and position of smp, twine thickness. Several studies have been carried out which have not clearly demonstrated any major differences, however, claims persist that smaller vessels are more susceptible to bad weather and do not have power in reserve to compensate for this. They also claim to have operational differences that reduce selectivity. Term of Reference d) Innovations are needed in the industry to cope with rising energy costs, the emerging demand for lower greenhouse gas emissions, and requirements deriving from the move to the ecosystem approach to fisheries management (such as reducing bycatch and seabed impact). More responsibility is being placed on industry to ensure they remain ahead of technology to cope with the changing world, and there are many examples of many initiatives being taken by fishers and equipment manufacturers. The trend is more and more to directly finance the industry in such endeavors, e.g. from the European Fisheries Fund (EFF), with the risk of a limited input from the scientific community. Tools are being developed to forecast ecosystem effects from introducing gear modifications and/or gear replacements in fishing fleets, e.g. the MAFCONS model on the effect on benthic communities in the North Sea (EU Project DEGREE). There is a role for a practical approach, but also a need for scientific input in the process in order to avoid that these developments lead

	to increasing fishing effort (technology creep) and pressure on already overexploited stocks and other possible adverse ecosystem effects. This will be limited to modifications to otter and beam trawls, gear replacement (e.g. alternative gears) aimed at reducing energy consumption, bycatch and/or seabed impact.
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 40–60 members and guests.
Secretariat facilities	None.
Financial:	No financial implications.
Linkages to advisory committees	The questions of bycatch reduction, gear selectivity, gear monitoring, fisheries information and survey trawl standardization are of direct interest to ACOM
Linkages to other committees or groups	This work is of direct relevance to the Working Group on Ecosystem Effects of Fishing Activities, Working Group on Fishery Systems, International Bottom Trawl Survey Working Group, SSGESST and SSGSUE and the Assessment Working Groups.
Linkages to other organizations	The work of this group is closely aligned with similar work in FAO, GFCM, NAFO and also the EU Regional Advisory Councils.

Annex 5: Study Groups

WGFTFB recommend that a **Study Group on Electrical Fishing** (SGEF), chaired by Bob van Marlen*, IMARES, The Netherlands be established and meet in (to be confirmed) to address the following ToRs:

a) To review current technical developments on electrical fishing (with the main focus on marine fisheries).

b) To review studies on the relationship of pulse characteristics (power, voltage, pulse shape) and thresholds in terms of effects on fish and other organisms (mortality, injury, behavioural changes).

c) To improve knowledge of the effects of Electrical Fishing on the marine environment (reduction of bycatch, impact on bottom habitat, impact on marine fauna, energy saving and climate related issues).

d) To evaluate the effect of a wide introduction of electric fishing, with respect to the economic impact, the ecosystem impact, the energy consumption and the population dynamics of selected species.

e) To consider whether limits can be set on these characteristics to avoid unwanted effects (e.g. unwanted and uncontrolled growth on catch efficiency, unwanted ecosystem effects) once such systems are allowed and used at wider scale.

SGEF will report by XXX 2011 (via SSGESST) for the attention of the SCICOM.

Supporting Information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification and relation to action plan	Action Item 3.2, 3.13, 4.11.3, 4.13, 5.11 Term of Reference The use of electricity in fishing is currently banned in EU regulations due to concerns on the impact and efficiency. Several countries, however, notably the Netherlands and Belgium have been testing the potential for electrical pulse trawl systems to replace conventional beam trawls, which are classified as having high environmental impacts. Such systems are currently being tested under deogartion on commercial vessels and the results of the Dutch trials have been reviewed by ICES and STECF. A number of This involves substantial investments that are stimulated by the Dutch Ministry LNV. In order to lift this ban and/or continue to work under derogation additional information on ecosystem effects of introducing this technique in the EU beam trawl fleets was requested by ICES and the EU's STECF in 2006. Since 2006 additional trials have been conducted to try to address the issues raised by ICES and STECF and the results to need be reviewed to assess whether the concerns raised have been satisfied. There is a lack of data on the response thresholds for various species and length classes, describing the power limits for survival and reproduction of fishes. Pulse trawling is currently being developed for other species than flatfish i.e. brown shrimp (*Crangon crangon* L.). Consequently a growing number of (European) fishing vessels is potentially involved, with a considerable value in terms of landings. There is a need for clearer and more extended identification of limits in defining regulation than the two (power per unit of length and maximum voltage) currently in use in the present EU-derogation for use of electrical fishing in The Netherlands. There is interest in fishing with electrical

	stimuli on otherspecies, e.g. Atlantic razor clams (Ensis directus L.).
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 Study Group will be attended by some 10–12 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	There are no obvious direct linkages with the advisory committees
Linkages to other committees or groups	This work is of direct relevance to the Working Group of Fishing Technology and Fish Behaviour, WGCRAN, WGECO and WGNSSK.
Linkages to other organizations	There is a very close working relationship with all groups of SSGESST.

Annex 6: Workshops

It is recommended that a **Workshop on seine net selectivity** (WKSEINE) of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) be held in Scotland on (to be determined) chaired by Dominic Rihan BIM, Ireland and Barry O'Neill, Marine Scotland, UK, to address the following ToRs:

a) Collate selectivity data relevant to current seine net fisheries using regional or geographic grouping, if appropriate;

b) Consider and identify suitable analytical techniques for further analysis of these data given its inherent variability;

c) Investigate diamond and square mesh codend data and square mesh panel (size and position) and other selectivity devices deemed appropriate and compare this with data from comparable trawl fisheries.

WKSEINE will report by XXX 2011 (via SSGESST) for the attention of the SCICOM.

Supporting Information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Scientific justification and relation to action plan	Action Item 3.2, 3.13, 4.11.3, 4.13, 5.11 Term of Reference a) Seining, either fly-dragging or anchor seining are considered to be "environmentally friendly" fishing methods with a number of positive benefits. Following on from the work carried out by WGFTFB in 2009 and 2010 it was identified that there was a need to further analyse existing selectivity data and compared this with trawl selectivity data to assess whether seine nets are more or less selective and therefore treated differently when setting mesh size regulations. In addition a number of studies were identifed that looked at the use of selective devices including grids and square mesh panels in seine net gears. The results from many of these trials were inconclusive and WGFTFB feel there is a need to review these experiments and assess whteher such selective devices are appropariate tools for improving seine net selectivity.
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 Workshop will be attended by some 10–12 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	There are no obvious direct linkages with the advisory committees
Linkages to other committees or groups	This work is of direct relevance to the Working Group of Fishing Technology and Fish Behaviour
Linkages to other organizations	There is a very close working relationship with all groups of SSGESST.

Annex 7: WGFTFB information for other ICES expert groups – questionnaire sent to WGFTFB members

Rationale:

Over the past few years, the nature of the advice ICES has been requested to provide by the client commissions e.g. Norway, EU, and NAFO has changed considerably.

ICES is now asked to provide advice that is more holistic in nature, including information on the influence and effects of human activities on the marine ecosystem.

From the fishing technology perspective this includes information on how fishers are responding and adapting to changes in regulatory frameworks e.g. the introduction of effort control; technological creep; fleet adaptations to other issues e.g. fuel prices etc.

In response to this WGFTFB initiated a ToR in 2005 to collect data and information that was appropriate to fisheries and ecosystem based advice, coordinated by Dominic Rihan (Ireland).

In 2006, the FAO-ICES WGFTFB was formally requested by the Advisory Committee on Fisheries Management (ACFM) to provide such information and to submit this to the appropriate assessment working group.

This type of information is becoming more and more important at both international and national levels. It demonstrates that the community of gear technologists have an important role to play in this and that our expertise is considered to be highly valued.

Please note that this is intended for WGFTFB members from countries that receive their stock/fisheries advice from ICES.

It would be greatly appreciated if you, in collaboration with whoever necessary, fill out the questionnaire.

Thank you for your time and effort

Dominic

Introduction

This contains a series of questions relating to recent changes within the fleets in your particular country that you may have observed. It also gives you the opportunity to raise any issues that you think are important but are not currently recognized.

If at all possible, please try to quantify your statements or state how the information has been derived e.g. common knowledge, personal observations, discussions with industry etc. Please try to keep your comments restricted to information in the period 2008–2010.

*a. Changes in Fleet Dynamics between **2008 and 2010***

Has there been any geographical or temporal shift in activity, change in gear type or shift in target species?

What are the principal driving factors for this change? (e.g. management measures, effort allocation, fuel costs)

Has there been any removal of effort through decommissioning schemes, if so which fleets have been affected and has the decommissioning affected older or newer vessels or a combination of both? If so what proportion of the fleet has opted for decommissioning (express as a percentage of the total fleet?)

Have any new vessels entered the fleet?

b. Technology Creep

Include such issues as new gear handling methods/equipment; switch from single to multiple trawling for example; changes in vessel design that could affect effort etc; new fish finding equipment.

Have there been any significant changes in gear usage in specific fisheries, if so what are the changes (e.g. switch from twin to single rig trawling, beam trawl to seine net).

In which fishery has this occurred and in what ICES areas?

Have any other technical changes occurred in particular fleets that will have resulted in changes in catching efficiency (e.g. changes in fishing pattern, new gears or navigational equipment). Has the change in catchability been quantified?

Is there any evidence of vessels adapting their operations to improve fuel efficiency?

c. Gear Based Technical Conservation Measures

Other important information could include what is the level of uptake if voluntary, has the selectivity of these been determined and if so how does it compare with the earlier estimates, are there any other wider benefits e.g. reduced fuel costs, ecosystem benefits etc.

Have any new TCM's been introduced into specific fisheries? If so what are the measures and which fleets and/or areas are affected? Please specify regulation (national or otherwise) and fishery. Have individuals or groups of fishers introduced TCM at their own initiatives, and why?

Have any incentives been introduced to promote the use of more selective gears? If so which fleets/areas are targeted and what are the incentives (e.g. additional effort allocations for use of Swedish grids/SMPs)

Can the changes in selectivity (size or species) be quantified relative to 'standard' gears; if so what are the changes (e.g. shift in L50, % reduction in bycatch)

What proportion of the fleet has opted to use new TCMs (0–5; 5 highest)

d. Ecosystem Effects

Are there any fisheries not previously reported where there are known impacts on non-target species including seabirds and marine mammals, ghost fishing etc?

Are there any measures in place to reduce benthic impact?

Are there any mitigation measures in place and how effective have they been?

Is there any change in discard patterns in the fishery?

e. Development of New Fisheries

Briefly describe any new fisheries developed in the period 2008–2010?

Have these new fisheries removed effort from others, and if so can you provide an estimate (in terms of numbers of vessels) of how many?

Please return both files prior to the WGFTFB meeting by e-mail to Dominic Rihan (Rihan@bim.ie) and use a country code identifier in the file name e.g. Norway.doc. Your information will then be collated into a common format.

FTFB report to WGCSE and WGHMM

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Northern Shelf and Southern Shelf Assessment Areas including the Irish Sea and the Celtic Sea.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Northern and Southern Shelf fisheries; information was obtained from Ireland, the UK-Scotland, Belgium, Netherlands, France and Spain and UK England, Wales and Northern Ireland.

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Southern Shelf for hake, monkfish and megrim stocks.

Fleet dynamics

- As in 2009 all countries have reported very low prices for fish and shellfish. Indications are that prices for some species have stayed at levels in excess of 50% of 2007 prices. In many countries vessels have tied up and most markets continue to be depressed. Imports are put forward by industry as the main reason. The one exception has been the market for frozen *Nephrops,* which had been depressed in 2009 has picked up significantly in 2010 with prices of up to €37/kg being recorded. (All countries: Implications: Reduced effort).
- Quite a number of Irish vessels are now equipped to freeze at sea and several more are in the process of installing freezing equipment. If every vessel which is planning to install equipment does so there will be approx 22

boats in the Irish fleet with the option of freezing. This will undoubtedly have implications for the *Nephrops* fisheries as most of these vessels are efficient 20m+ vessels fishing with twin-rig double codend trawls (Ireland: Implications: Increased effort on *Nephrops).*

- Several of the larger Irish vessels (20–24m+) operating in Area VIa have been forced to move to Area VIIb-k due to a lack of days at sea. This is partially due to the reductions in effort required under the LTMP for cod becoming a limiting factor but also as a result of the allocation system being used in Ireland which gives a flat rate allocation to all vessels with a track record regardless of recent fishing activity. This shift of effort has put more pressure on Celtic Sea whitefish stocks (Ireland: Implications: Shift of effort from VIa to VIIb-k).
- In ICES area VIa there has been a continuation of the trend to work in and around the "French line" as much as possible to maximize vessels days-at-sea allowance. This is most prevalent during winter and spring months when the monkfish fishery is at its peak. Another option to save days allocation in 2009 and 2010 has been for vessels to target Rockall which is outwith the days at sea regime. (Scotland: Implications: increased effort along the shelf edge and Rockall)
- Scottish vessels traditionally targeting cod, haddock and whiting fish east of the French line have been severely affected by the 30% bycatch limits, which have effectively closed these fisheries. Trips in this area are no longer viable because of the lack of alternative economically viable species to make up the other 70% of catches. These vessels have either reverted to the North Sea or switched to *Nephrops* fisheries. (Scotland: Implications: Shift in effort in VIa).
- The Scottish twin-trawl *Nephrops* fleet continued to re-new with six new larger powered vessels replacing older low powered vessels in 2009/2010. In addition the < 10m fleet sector (pots) there was 16 new boats replacing older vessels. (Scotland: Implications: New efficient vessels).
- Due to a combination of fuel costs, low fish prices and quota restrictions in Spain a number of larger operators are in financial difficulties. Despite strong political support, there are reports of commercial difficulties and numbers of skippers are leaving the industry. During 2009 six 40m freezer vessels were sold to Norway. (Spain: Implications: Reductions in capacity).
- The table below shows the evolution of the French fleet since 2007 following decommissioning programmes.

LENGTH OF THE BOAT	2007	2008	EVOLUTION %
< 7 m	1258	1219	-3%
7 to 9 m	1269	1250	-1%
9 to 12 m	1408	1387	-1%
12 to 16 m	452	421	-7%
16 to 20 m	255	212	-17%
20 to 24 m	281	255	-9%
24 to 40 m	205	192	-6%
40 m and more	52	50	-4%
Total	**5180**	**4986**	**-4%**

Source Ifremer - Synthèse des flottilles de pêche 2008 – SIH.

- A number of vessels in the French fleet there has been a shift from purse seining (tuna) and trawling (mixed demersal) to Danish Seining (Fly-dragging) in the Bay of Biscay in Area VIII. One purse-seiner in the period 2007- 2009 and 1 trawler in 2008, 3 other trawlers in 2009 and 6 new builds in 2010 (designed for Danish seining + trawling). (France: Implications: Shifts in effort in Area VIII).
- Three French gillnet vessels have diversified (Northern Bay of Biscay, VIIIA) to *Nephrops* potting. The main motivation is reduced costs and better prices for a high quality product. (France: Implications: Shift in effort to a low impact fishing method).
- The closure of the "porbeagle shark" (*Lamna nasus*) fishery in the Bay of Biscay has affected ~ 3 vessels from the Ile D'Yeu region. It is unclear what these vessels will now target (France: Implications: Closure of fishery causing likely shift in effort).
- With the increased restrictions on bluefin tuna a number of French vessels in CECAF Areas 37.1.1 and 37.1.2 have changed from drift gillnets for Bluefin Tuna to longlining or trammel netting for Dover Sole. (France: Implications Shift in effort in CECAF 37.1. and 37.12).
- In Belgium nine beam trawlers from the large segment (>300 HP) have been decommissioned, of these 2 have been 'partially decommissioned' replaced by two new gillnetters. By number, 10% has opted for decommissioning. This is 11% reduction of the total horsepower and 13% of the total GT of the Belgian fleet. Two new gillnetters have entered the fleet and one gillnetter/otter trawler. (Belgium: Implications: Reduction in effort).
- There were limited experimental trials by Belgium vessels for gillnet fisheries in ICES-subarea VIIf. In 2010, further experiments will be conducted especially with pots for cuttlefish. (Belgium: Implications: Move away from beam trawling to other fishing methods).
- In the UK a geographical shifting of the under 10m fleet has been seen in the last couple of years as vessels (trawlers from the NE and Netters from the SW of England) that have historically worked from a single port have had to shift to other areas due to quota availability within the under 10m pool. Target species have generally remained the same but movement to other areas have allowed the vessels to target species not currently available on their home grounds, i.e. *Nephrops* in the NE or have access to

higher quota allocations by moving to an adjacent ICES rectangle. None of the changes reflect a change in the distribution patterns of fish it is all down to regulatory pressures and quota availability within the under 10m pool. (UK: Implications: Shifts in effort by < 10m sector).

- In the SW of England, rather than specific gear changes, UK fishers have tended to become more flexible in their approach to fishing, building in the ability to change gears and fisheries as opportunities become available. A good example of this is the static netting fleet that switch between Hake netting, tangle netting, wreck netting and trolling for tuna during summer. The largest netter currently working out of Newlyn has this spring rigged out for tangle netting for the first time since the vessel was built over 10 years ago. (UK: Implications: Vessels moving from one métier to another).
- Also in the SW England fleet, there are fewer under 10m "rule beaters" working pressure stocks, as they have either left the industry or diversified to other sectors. The number of beamers has also steadily declined. A decommissioning scheme for the under 10m vessels during 2008 affected a cross section of the fleet taking out both new and older vessel. A rough estimate of the proportion of the fleet decommissioned would be 2–3%. Of the vessels that decommissioned at least half of these owners have since bought another under 10m vessel and re-entered the fishery. (UK: Implications: Changes in the structure of the fleet).
- Since 2008 the only expanding sector of the UK fleet, with respect to the SW is the 6–8m sector of the under 10m fleet. These vessels tend to be single handed targeting mackerel, bass and pollock with handlines and various species using static gear. Due to the relatively low start up costs fishers have either downsized from owning larger boats or have moved from working on the larger class of vessels. (UK: Implications: Reduction in vessel size).
- The Closed season for the Gulf of Cadiz Otter trawl fleet fishery has been increased to 90 days, in two periods: 60 days from mid-September to mid-November and 30 days from mid-January to mid February. The increased biomass of fish stocks resulting from this closure is shifting effort into coastal resources, thereby saving energy and homogenization of landings. It has been noted an increasing trend in the abundance of white shrimp (*Parapenaeus longirostris*) and effort has been shifted away from *Nephrops* onto this species. (Spain: Implications: Shift in effort from *Nephrops* to white shrimp).
- The Basque trawler fleet did not fish in Area VII by trawl fleet with effort has been concentrated in divisions VIIIabd. During 2010 an increase of the effort by this fleet in Area VI has been observed. (Spain: Implications: Shifts in effort pattern).
- The Basque pair trawl fleet targeting hake have made shorter trips than usual recently, due to a low market price. Shorter fishing trips improved the fish freshness. Also vessels have coordinated entry into base ports sequentially during the week, avoiding landing all catches in the same traditional two days of the week (Monday-Thursday). In this way, fish auctions take place throughout the week which should raise the market price of the catch. (Spain: Implications: Different fishing pattern on hake).

- During 2009, five single trawlers have been decommissioned (20% of the Basque trawler fleet). Two of these trawlers were 10 years old. One second hand vessel (single bottom trawler) has been bought from Galicia in 2010. (Spain: Implications: Reduction in effort).
- In Ireland safety regulations enforced by the Marine Survey Office have meant nearly 50 Irish vessels > 15m being tied up for periods of up to 2–3 months to meet the requirements under a Code of Compliance. Vessels have their fishing licence suspended until the vessel passes the inspections carried out by the MSO. Several vessels have been effectively decommissioned as to pass the inspections would be too costly. This has effectively decreased effort. (Ireland: Implications: Decrease in effort).

Technology Creep

- Up to 4 Irish vessels in the 20–24m+ range are now using semi-pelagic trawls to reduce fuel consumption and by design less bottom contact. These doors are worked "off-bottom" with an intermediate weight placed at the midpoint of the bridles. These vessels re mainly targeting mixed species such as monkfish, megrim and hake and catches seem unaffected by this modification while slight improvements in fuel efficiency have been reported. (Ireland: Implications: Low impact trawl doors).
- In Scotland a number of vessels have applied to the European Fisheries Fund (EFF) in order to modify their vessels to become more fuel efficient at different ways. This trend is likely to continue and involves a range of modifications (Scotland: Implications: Fuel efficient vessels)
- There is increasing interest from French fishers to switch to fish pots. This is a combination of voluntary fishing combined with experimental trials. The main motivation for this is decreased costs and higher prices for fish landed. (France: Implications: Adoption of a low impact fishing method).
- There has been an increase in the use of stone traps ("rock-grids") in *Nephrops* twin trawls used by the French fleet. As a consequence, rocks are spread in the fished area, increasing the risk of net damage for other trawlers. Also, this device makes possible the fishers to work on harder bottoms. (France: Implications: Adaptation to prevailing bottom conditions).
- There have been a number of initiatives taken in France to improve fuel efficiency these include: new optimized doors, which fish "off-bottom"; optimized shaping of the trawls, increasing meshes when possible in the aft part of the trawls and using low drag materials such as Dyneema and Breizline twines; and also decreasing speed in transit and fishing (for example keeping a constant pressure of the turbo when fishing, without considering the speed over the ground); and also avoiding transiting against the tide/current where possible. (France: Implications: Changes in fishing pattern/improved fuel efficiency).
- There have been some seasonal changes to operations in the Belgium fleet. As in previous years, some beam trawlers switch to outrigger gear during summer in VIIf, VIIg and IVc. One beam trawler has been replaced by a seine netter (flyshooter), formally a French vessel. From 2007 to 2009 several beam trawlers have fitted net drums to enable the vessel to switch to twin-rig for plaice on a seasonal basis mainly in the North Sea. Three beam trawlers have been converted to scallop dredgers (of which one has al-

ready re-converted to beam trawling). (Belgium: Implications: Vessels switching between métiers).

- With reduced fuel prices, V-netting has regained importance in the Belgium beam trawl fleet (as opposed to 2008). (Belgium: Implications: Unknown).
- As in last 2009 More and more Belgium and Dutch beam trawlers are equipped with 3D mapping sonar which has opened up new areas to fishing (close to wrecks). (Belgium and Netherlands: Implications Opening up of new grounds).
- Ground discrimination technology is becoming increasingly important to all sectors of the UK fleets. An increasing number of vessels are fitting systems such as Olex in an attempt to open up new grounds as fishing opportunities diminish. (UK: Implications: Opening up of new areas).
- In the Basque fleet there have been continued attempts to improve fuel efficiency. Vessels have begun to use fuel efficient gears such as purseseines, gillnets, handlines. They have also adopted different behaviour such as reduced steaming speeds to reduce fuel consumption and also the installation of fuel monitoring equipment on board. (Spain: Implications: Improved fuel efficiency).

Technical Conservation Measures

- Three Irish vessels (~20m/350kw) are now using the "Swedish" sorting grid in the *Nephrops* fisheries in the Irish Sea (Area VIIa). Based on a case submitted by the Irish government these vessels are now exempt from effort restrictions currently in force in this area. The observations carried out showed cod catches with the grid to be consistently less than 0.1% per trip. It is hoped other vessels will follow (Ireland: Implications: Voluntary uptake of cod friendly gear).
- In addition to the 3 Irish vessels using grids, 6 other Irish vessels are using the inclined separator panel in the Irish Sea. Under the current effort management plan in place these vessels are receiving additional days over and above other vessels. The fish catches from these vessels are being closely monitored to ensure that the separator panel is not being circumvented which can be easily done by lacing up the escape hole at the top of the panel (Ireland: Implications: lower cod catches).
- Several Irish trawlers who are freezing *Nephrops* on board are using 120mm square mesh panels in their trawls when fishing on the Porcupine grounds. These vessels report high concentrations of argentine, boarfish and blue whiting on the grounds that are of no commercial value. (Ireland: Implications reduce discarding of non-target species).
- Irish vessels operating inside the restricted area in Area VIa, particularly on the Stanton Bank grounds have reported that the 120mm codend mesh size required in this area is causing a large quantity of their legal megrim catch to be damaged due to gilling. This has also been reported by Scottish fishers. This makes this fishery uneconomic and the fishers have asked for a review of this regulation in light of low cod catches in this area (one vessel landed 120kg cod from 96 tows; Ireland/Scotland Implications: Fish damage due to mesh size regulations).

- The industries in a number of countries have reported problems with the implementation of the OMEGA mesh gauge. It is claimed that this gauge gives measurements of ~5% or more less than the wedge gauge previously used by fisheries inspectors. The industry claims the introduction of this gauge is effectively an increase in mesh size and also that fishers have been forced to replace codends which prior to the new regulations were perfectly legal. Similarly netmakers have been forced to dump netting as it is no longer legal. In Scotland skippers have replaced codends constructed from mesh sizes which are 8mm to 10mm greater than pre-Omega gauge introduction effectively increasing codend selectivity. (All countries: Implications: Control and enforcement issue/ Possible changes to selection pattern).
- The UK Conservation Credits Scheme made available options to buy back additional days at sea for both TR1 and TR2 vessels that adopted the exclusive use of selective gears in the Scheme years 2009/10 and 2010/11 in both West of Scotland (WoS) and the North Sea (NS). The table below sets out the incentives offered for both Nephrops and whitefish gears targeting NS and WoS grounds. Uptake of selective gear buy backs under CCS in 2009/10 was modest (1). Uptake has increased so far in 2010/11 fishing year as effort restriction impact on vessels. So far (May 2010) 20 TR1 NS vessels using Orkney Trawl, 20 TR2 NS vessels using 120mm SMP and 7 TR1 NS vessels using 130mm codend (Scotland: Implications: Voluntary use of more selective gears)
-

AREA	NS		WOS	
GEAR CATEGORY	WHITEFISH	PRAWN	WHITEFISH	PRAWN
	BUY BACK IN DAYS			
Optional spatial conservation credit measures				
Fishing exclusively outside amber areas	8	8	0	8
Optional gear conservation credit measures				
Use of Eliminator trawl (WF)	24		24	
Use of Orkney trawl (WF)	20		20	
130mm codend (WF)	8		8	
Nephrops SMP (prawn)		8		4

- Eight different selective gear designs have been compared successively to a standard commercial trawl In the mixed Hake-*Nephrops* fishery of the Bay of Biscay by Ifremer in France during spring 2009: 2 square mesh cylinders (62 and 70mm), a combination of grid and square mesh panels, 2 settings of Radial Escape Sections (RES), and 3 rig designs to force the mesh opening (2 settings of 75% hanging ratio and T90). All devices have been observed with underwater video systems. The catch comparison analysis for the square mesh cylinder showed a good escape rate for juvenile hake with a relatively low loss of *Nephrops*, either below or above MLS. The grid and square mesh panels combination was efficient at releasing both, juvenile of *Nephrops* and hake with low escapement of commercial individuals. The

escapement rate with the RES was highly dependent and sensitive on its setting. The opening mesh designs appeared to be non-adapted to the mixed fishery with a very high escape of commercial *Nephrops*. (France: Implications: Improved selectivity).

- In the SW England fleet there has been a move among different types of vessels to use bigger mesh in top panels of the gear as well the use of larger mesh square mesh panels (~100–120mm). There are also now 15 vessels (beam trawlers) on the south coast using square mesh codends to reduce discarding. (UK: Implications: Improved selectivity through voluntary use of TCMs).
- Recognition through initiatives such as "Project 50%" (See 18.1.3) on beam trawlers and trawlers in the SW of England using skippers' ideas in ways to reduce discards have been quite successful. Methods adopted have included the use of larger mesh in both the top sheet and belly, benthic panels and square mesh. The incentive for fishers where that gear was made available to the skippers own specifications and also improved public perception of their operations. (UK: Implications: Reduction in discarding).
- In the SW England fleets that are also indications that market incentives are increasing in terms of including fishing methods and TCMs. For example there is a continuing move away from mobile and towards static gear, strong expectations that beamers will use benthic release panels and rollers, strengthening unease with high levels of discards. This is expected to become stronger and more effective over coming years. (UK: Implications: Voluntary use of TCMS).
- Under national legislation there has been an increase in the mesh size from 40 mm to 55 mm in the Gulf of Cadiz Bottom Otter Trawl Fishery. (Spain: Implications: Unknown but likely to reduce discarding).
- The closure on the Porcupine Bank to protect *Nephrops* has reportedly resulted in high degree of effort around the borders of the closed area. The general size range of *Nephrops* has reduced dramatically as effort has intensified in these areas. (Ireland: Implications: Increased effort around a closed area).

Ecosystem Effects

- A number of fishers have reported very high levels of Anisakis worms being found in hake in the last 6–8 months. Counts as high as 17 per kg have been reported and this has resulted in a much lower price for hake. Changes to handling practices including holding the fish in slush ice prior to gutting and also gutting immediately on landing on deck have been tried to reduce the problem (Ireland: Implications: Parasitic worm problem).
- Predation of fish catches by mainly Grey seals form gillnet/tangle net fisheries continues to become a problem on all coasts of Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high. Seals have been reported up to 80–90 miles off the coast. More than 30 vessels in the size range 10–20m are affected by this phenomenon. One vessel operating in Area VIa has reported that seals are not only targeting gillnets but also vessels jigging around wrecks and rough ground for white pol-

lack. (Ireland: Implications: Unaccounted mortality caused by seal predation).

- Irish vessels fishing at Rockall (VIb) in Q1 and Q2 of 2010 report that haddock catches have reduced by 30–40% on previous years. There seems to be a scarcity of small haddock on the grounds and the vessels also report no Russian activity in international waters as in previous years. However, the vessels are reporting good signs of cod in the area, as well increased catches of monkfish and megrim. (Ireland: Implications: Reduction in haddock but increase in cod, monkfish and megrim).
- Irish vessels operating in VIa both inside and outside the restricted area (French Line) have reported very good signs of megrim and hake. They report catches at levels not seen since the 1990s. Catches seem to have increased along the shelf edge for these two species. Similarly 4–5 Irish gillnetters still in operation have enjoyed very good fishing for hake between 70 and 100 miles SW of the Mizen. Prices are poor but the large volumes (300–400 boxes for four hauls) are compensating for the bad price. (Ireland: Implications: Increased abundance of hake and megrim in VIa and VIIb-k).
- In VIa in 2010 Scottish vessels have reported poor monkfish catches and many areas seem to show unusually large numbers of Lesser Spotted Dogfish (*Scyliorhinus Canicula*) and Red (*Aspitrigla cuculus*) and Grey Gurnard (*Eutrigla gurnardus*). All Common Skate (Blue Skate, *Raja batis*) are now being discarded. There remains a tendency to "high grade" for species such as cod and hake as continued low quota and poor prices make it financially unattractive to land the smaller sizes. In addition to this unstable megrim prices in 2010, have also seen vessels discarding bruised Megrim. (Scotland: Implications Increased discarding/High-grading).
- There continues to be a reported cetacean bycatch in the French sea bass and Albacore tuna pair pelagic fisheries. This bycatch has reduced from peak levels but nonetheless still exists. Trials with a range of acoustic deterrent devices are continuing. (France: Implications: cetacean bycatch).
- Belgium beam trawlers are continuing to voluntary use "alternative" beam trawl, i.e. beam trawl with technical modifications (T90-codend, Benthos Release Panel, big meshes in the top panel). The initiative has been continuing since 2008. A better size and species selectivity is expected, as well as a discard reduction of benthic invertebrates. In addition the increasing use of the SumWing is supposed to reduce the impact on the seabed. (Belgium: Implications: Improved selectivity and reduced benthic impact).
- There is a lot of debate in the SW England on MPAs. Many fishers see access to grounds is most likely to be easier for static gear in future. This is a very dynamic situation and outline management plans are being drafted currently. Fishermen are fearful they will be put out of large areas. (UK: Implications: Development of MPAs with restricted fishing).
- Work is still ongoing in both the UK inshore and offshore static netting fisheries looking at the reduction of cetacean by catch. The Sea Mammal research Unit is carrying out trials with the 'DDD-super pinger' in the off shore fishery and the Cornwall wildlife trust is carrying out trials with the Aquatic pinger in the SW inshore fishery. Results are encouraging although there are issues still to be resolved with the reliability, range,

safety, attachment and deployment within specific fisheries.. (UK: Implications: Mitigation of cetacean bycatch).

- A new closure in the Hatton Bank in ICES Areas XIIb and VIb1 to protect cold-water corals has impacted on several Spanish deep-water trawlers. (Spain: Implications: Closure of area).
- As in other countries Basque fishers have begun experimenting with off-bottom-trawl doors, primarily to save fuel but with resulting reduction in bottom impact. (Spain: Implications: Reduced bottom impact).
- A number of Irish fishers have reported catching increasing quantities of small cod in shrimp pots. This is widespread over a large area of the south coast of Ireland. (Ireland: Implications: Abundance of small cod).
- There is widespread reporting of discarding of juvenile haddock in the Celtic Sea. Irish fishers have reported haddock in the size range from 20–23cm to be abundant on grounds on the south coast leading to widespread discarding. (Ireland: Implications: Discarding of small haddock).
- Irish inshore vessels have reported spurdog to be plentiful in Area VIa and VIIb in 2009 and 2010 contrary to scientific advice. Due to a zero quota for this species, however, they are forced to discard this species. (Ireland: Implications: Discarding of spurdog).
- The ratio of female to male *Nephrops* in the Porcupine Bank fishery according to fishers has changed markedly from being predominantly females in 2009 to more than 75% male in 2010. (Ireland: Implications: Unknown).

Development of New Fisheries

- The French scallop industry is attempting to develop dive fishing for scallops in Northern Brittany. Five vessels used to prosecute a fishery for abalone by diving and have managed to obtain licences to dive for scallop in 2008 in the Rance River. In 2010, they have also been allowed to fish scallop in one area near Saint Malo. The legislation that applies to these vessels is almost the same than as for scallops dredging in terms of catch and effort limitations. In another area in Northern Brittany (area open only 15 days per year), fishers that received licences to dredge for scallop can also choose to dive for them instead. Uptake has been restricted to one vessel to date. (France: Implications: Low impact fishing method).
- One Belgium otter trawler is targeting squid in area VIId as an alternative for winter. Several Belgian netters have carried out trials with gillnets for turbot, cuttlefish pots and fish traps, experiments were partially successful and will continue in 2010. (Belgium: Implications: Limited new opportunities)
- An anchovy fishery has developed in the SW of England and a number of vessels looking to target the species when available. A proportion of these vessels tend to be multi-purpose netters or trawlers. The fishery tends to be a winter one and closer to the shore than they would normally work, so displacement from there standard fisheries can be seen as minimal. (UK: Implications: New fishery for anchovy).

FTFB report to WGNSSK

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the North Sea, Skagerrak and Kattegat.

It should be noted that the information contained in this report does not cover fully all fleets engaged in North Sea fisheries; information was obtained from Scotland, UK England, Wales and Northern Ireland, France, Belgium, Netherlands and Norway.

Fleet dynamics

- Scottish vessels traditionally targeting cod, haddock and whiting fish east of the French line have been severely affected by the 30% bycatch limits, which have effectively closed these fisheries. Trips in this area are no longer viable because of the lack of alternative economically viable species to make up the other 70% of catches. These vessels have either reverted to the North Sea or switched to *Nephrops* fisheries. (Scotland: Implications: Shift in effort in VIa).
- The Scottish twin-trawl *Nephrops* fleet continued to re-new with six new larger powered vessels replacing older low powered vessels in 2009/2010. In addition the < 10m fleet sector (pots) there was 16 new boats replacing older vessels. (Scotland: Implications: New efficient vessels).
- The table below shows the evolution of the French fleet since 2007 following decommissioning programmes.

LENGTH OF THE BOAT	2007	2008	EVOLUTION %
< 7 m	1258	1219	-3%
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40 m and more	52	50	-4%
Total	**5180**	**4986**	**-4%**

Source Ifremer - Synthèse des flottilles de pêche 2008 - SIH

- In the English Channel and North Sea: 8 French vessels (~4%) have been decommissioned by end of 2009. Two were fishing for Saithe (more than 30 years old - (area IV); one was a gillnetter (28 years old – area VIId); five were trawlers (20 to 26 years old – IV and VIId). (France: Implications: Reduction in effort).
- Since the end of 2007 due to the abundance of cod in the Eastern English Channel and south of North sea there was increase in effort by French

mixed demersal trawlers and netters, but since the end of 2009, due this stock has seemed to decline and the vessels have reverted back to their traditional fishing pattern (France: Implications: Not clear).

- Some of the smaller French trawlers (under 16 meters) normally using 80mm codends in area VIId are currently using dredges (beam trawls) targeting flatfish for part of the year. This would appear to be more effective than traditional trawls for targeting the species involved. (France: Implications: increased effort on flatfish species in VIId).
- Several larger French trawlers using mesh size range 70–99mm have continued to fish further north in the North sea (southeast of Scotland in Area IVb) because of the low abundance of whiting in VIId, and also to reduce fuel consumption by increasing the duration of their individual trip (from 2 days long to 4 or 5 days long; France: Implications: Shift in an effort from VIId to IVb).
- Two French netters from the port of Calais are now targeting whelks with pots (diversification). (France: Implications shift in effort from mixed demersal species to molluscs).
- The gradual shift from beam trawling for flatfish to twin trawling and fly-shooting (Danish seining) on other species e.g. gurnards, and *Nephrops*, etc. in the Dutch fleet is continuing. However, two vessels engaged in outrigging reverted to conventional beam trawling to catch their sole quota when plaice prices were too low. They may take up outrigging again depending on economics and quota. (Netherlands: Implications: Shifts in effort in the beam trawl fleet).
- The average number of days at sea fished by the Dutch fleet declined to 164 days (-7%). Most vessels were at sea for fewer days; only vessels in the category hp class 301–1500 were at sea for more days on average than last year. Total fuel consumption declined to a volume of 164 million litres (-19%). (Netherlands: Implications: Reductions in overall effort).
- According to the Dutch industry fuel costs are still high and income is under pressure. Of all the main fish species including sole, plaice, cod, turbot and brill, more is being landed (all fish +6%). The number of landed shrimps appears to be 20% higher in 2009, while *Nephrops* landings have stayed steady in 2008. The prices of all fish types were lower than 2008 on average by approximately 16%. The average price of sole tends towards € 9.50 per kg, € 0.50 lower than in 2008. In particular the price of plaice has fallen steeply. It is expected that the average price will not be over €1.40 per kg, a reduction of at least 30%. The price of shrimps was also very low in 2008. Over the whole year, at least a 30% lower price is expected, around 2.70 € per kg, so around € 0.34 less than the estimated cost price for shrimp cutters. The price of crayfish will be at least 25% lower at round € 4 per kg. (Netherlands: Implications: Possible increases in effort to counteract low prices).
- The total engine power for the entire Dutch fishing fleet declined significantly to 429,000 hp (-8%), mainly due to the decline in the number of (big) cutters and despite the inclusion of the other small high seas fishing vessels (described below).The cutter (beam trawler) fleet itself declined by 37 vessels (-11%) to 308 vessels. The average engine power per vessel declined by 8% to 779 hp. The total engine power used of this fleet went

down to 268000 hp, a fall of 10%. (Netherlands: Implications: Reduction in fishing effort).

- A new fleet segment was added to the Dutch fleet in 2009 (*"Other small high seas fishery")*. This part of the Dutch fleet (388 vessels) comprises vessels involved in gillnet fishing and various other high seas fishing as well as non-active vessels. In total, 217 vessels are considered to be active and 171 vessels are inactive. The total engine power amounted to 54,000 hp, of which nearly 27,000 hp was used actively in some way. In particular, gillnet fishing using small vessels has risen steeply in recent years. However, since September 2009 its growth has been limited by maximizing the number of licences and the number of nets per licence. Of the active small fishery fleet, 66 vessels took part in gillnet fishing and 151 vessels took part in other high seas fishery such as shellfish fishing in the North Sea, fishing with static vessels for lobster and eel in the coastal and delta zone, smelt fishing with seines. The number of sea days per vessel varied from 3 to 115 days. A considerable group of non-active vessels (177) uses the vessel to park quota. There were also vessels in use as an extra boat or as transport boat and these were not used for fishing. (Netherlands: Implications: Shift in effort into gillnet fisheries).
- The catchability of Dutch vessels using outrigger trawls was compared to conventional beam trawlers. Sole catches were much lower and plaice catches higher. The mean fuel consumption per unit of time was considerably lower than in conventional beam trawling, ratio 44.8%. Catches were only higher for plaice (PLE), 140.5% in ratio, but lower for sole (16.2%) and turbot (54.1%). Expressed per litre fuel the outriggers caught 42.9%. The earnings were higher expressed per litre fuel, i.e. 121.6% (gross), and 132.4% (net). (Netherlands: Implications: Unknown).
- The Dutch Ministry in collaboration with the Dutch Fish Product Board have limited the maximum engine power of Dutch fly-shooters and twin-riggers to 500 and 700 kW respectively from 2011. (Netherlands: Implications: Effort cap).
- Savings in fuel of 40–70% were also found in trials with Outrigger trawls in Belgium, whilst sole catches were also lower by 8–13% of the total catch. (Belgium: Implications: lower effort on sole).
- In 2010 the Dutch authorities allowed 6.6 million kW-days with beam trawling to be replaced with 2.2 million kW-days of twin-trawling and fly-shooting. Twin-trawl trips longer than one week are to be restricted by the new regulation that within a time span of two week a maximum of 10 days-at-sea can be made. The available days-at-sea are going to be split in two periods: June-Oct and Oct-February (Netherlands: Implications: Effort controls).
- In Belgium nine beam trawlers from the large segment (>300 HP) have been decommissioned, of these 2 have been 'partially decommissioned' replaced by two new gillnetters. By number, 10% has opted for decommissioning. This is 11% reduction of the total horsepower and 13% of the total GT of the Belgian fleet. Two new gillnetters have entered the fleet and one gillnetter/otter trawler. (Belgium: Implications: Reduction in effort).
- There were limited experimental trials by Belgium vessels for gillnet fisheries in ICES-subarea VIIf. In 2010, further experiments will be conducted

especially with pots for cuttlefish. (Belgium: Implications: Move away from beam trawling to other fishing methods)

- An active process is ongoing to collect quota rights from 2–3 older fishing units to be used by a modern vessel with increased fishing capacity, or by new vessels. Older vessels are decommissioned or otherwise taken out of active fishing to accommodate such replacement vessels. (Norway: Implications: Modernisation of the fleet).
- Up t30 Northern Irish vessels shifted from the Irish Sea to the North Sea in Q1 of 2010 due to better fishing opportunities. Due to a lack of quota, however, discarding of whitefish by these vessels has been high. (Northern Ireland: Implications: Shift in effort from VIIa to IV).

Technology Creep

- In Scotland a number of vessels have applied to the European Fisheries Fund (EFF) in order to modify their vessels to become more fuel efficient at different ways. This trend is likely to continue and involves a range of modifications (Scotland: Implications: Fuel efficient vessels)
- There has been an increase in the use of stone traps ("rock-grids") in *Nephrops* twin trawls used by the French fleet. As a consequence, rocks are spread in the fished area, increasing the risk of net damage for other trawlers. Also, this device makes possible the fishers to work on harder bottoms. (France: Implications: Adaptation to prevailing bottom conditions).
- There have been a number of initiatives taken in France to improve fuel efficiency these include: new optimized doors, which fish "off-bottom"; optimized shaping of the trawls, increasing meshes when possible in the aft part of the trawls and using low drag materials such as Dyneema and Breizline twines; and also decreasing speed in transit and fishing (for example keeping a constant pressure of the turbo when fishing, without considering the speed over the ground); and also avoiding transiting against the tide/current where possible. (France: Implications: Changes in fishing pattern/improved fuel efficiency).
- Up to 50 Belgium (10–15) and Dutch (35–40) beam trawlers have switched from conventional beam trawls to SumWings. This might have some effect on fishing grounds chosen, and effort by time gains in shooting and hauling gears. In addition gear can be towed faster with the lower gear drag. The catching performance of SumWings has been compared with conventional tickler chain beam trawls. No major differences were found, when ticklers chains are kept the same. Some skippers report that they can haul in faster due to lower gear drag and achieve an additional 2 hauls per week trip. Other say they can fish in areas where difficulties arose with the conventional beam trawls, and that gear fasteners occurred to a lesser extent. The SumWing technology is still to be adapted to fishing in very uneven grounds (sandy peaks) in the southern North Sea. New wing designs were produced in early 2010. Examples are the so-called 'JackWing'. (Netherlands: Implications: More efficient beam trawls).
- The Dutch industry is continuing to test hydrodynamical stimulation (HydroRig) in the beam trawl fishery. Comparative fishing trials will be carried out this year. (Netherlands: Implications: Fuel efficient beam trawls).

- Through various innovations, individual cutters are saving fuel, ranging from 10 to 30%, with the occasional cutter achieving 45–50%. Developments related to the hydro-rig, eco-catcher, pulse and SumWing technology, in particular, are progressing rapidly and expectations are high among many Dutch flatfish fishers. The combination of pulse trawling and SumWings appears to enable a reduction in fuel consumption of about 60% to about 15000 litres per week. (Netherlands: Implications: Improved fuel efficiency).
- There have been some seasonal changes to operations in the Belgium fleet. As in previous years, some beam trawlers switch to outrigger gear during summer in VIIf, VIIg and IVc. One beam trawler has been replaced by a seine netter (flyshooter), formally a French vessel. From 2007 to 2009 several beam trawlers have fitted net drums to enable the vessel to switch to twin-rig for plaice on a seasonal basis mainly in the North Sea. Three beam trawlers have been converted to scallop dredgers (of which one has already re-converted to beam trawling). (Belgium: Implications: Vessels switching between métiers).
- With reduced fuel prices, V-netting has regained importance in the Belgium beam trawl fleet (as opposed to 2008). (Belgium: Implications: Unknown).
- As in last 2009 More and more Belgium and Dutch beam trawlers are equipped with 3D mapping sonar which has opened up new areas to fishing (close to wrecks). (Belgium and Netherlands: Implications: Opening up of new grounds).
- In 2009 a semi-pelagic trawl technique for saithe was successfully developed and introduced in the Norwegian fishery. The most successful trawl is designed with hexagonal front part meshes and rigged with pelagic trawls off bottom. Better efficiency, less fuel consumption and reduced bottom impact are reported, but presently not quantified. (Norway: Implications: Increased fuel efficiency and lower bottom impact).
- Rigging of trawl doors off-bottom is becoming increasingly common among several traditional bottom-trawl fisheries in Norway (Trawling for Saithe, Norway Pout and Sandeel are included). (Norway: Implications: Reduce bottom impact).

Technical Conservation Measures

- The industries in a number of countries have reported problems with the implementation of the OMEGA mesh gauge. It is claimed that this gauge gives measurements of ~5% or more less than the wedge gauge previously used by fisheries inspectors. The industry claims the introduction of this gauge is effectively an increase in mesh size and also that fishers have been forced to replace codends which prior to the new regulations were perfectly legal. Similarly netmakers have been forced to dump netting as it is no longer legal. In Scotland skippers have replaced codends constructed from mesh sizes which are 8mm to 10mm greater than pre-Omega gauge introduction effectively increasing codend selectivity. (All countries: Implications: Control and enforcement issue/Possible changes to selection pattern).

- The UK Conservation Credits Scheme made available options to buy back additional days at sea for both TR1 and TR2 vessels that adopted the exclusive use of selective gears in the Scheme years 2009/10 and 2010/11 in both West of Scotland (WoS) and the North Sea (NS). The table below sets out the incentives offered for both Nephrops and whitefish gears targeting NS and WoS grounds. Uptake of selective gear buy backs under CCS in 2009/10 was modest (1). Uptake has increased so far in 2010/11 fishing year as effort restriction impact on vessels. So far (May 2010) 20 TR1 NS vessels using Orkney Trawl, 20 TR2 NS vessels using 120mm SMP and 7 TR1 NS vessels using 130mm codend (Scotland: Implications: Voluntary use of more selective gears)

Area	NS		WoS	
Gear category	Whitefish	Prawn	Whitefish	Prawn
	buy back in days			
Optional spatial conservation credit measures				
Fishing exclusively outside amber areas	8	8	0	8
Optional gear conservation credit measures				
Use of Eliminator trawl (WF)	24		24	
Use of Orkney trawl (WF)	20		20	
130mm codend (WF)	8		8	
Nephrops SMP (prawn)		8		4

- The French have been carrying out trials in the Channel and North Sea looking at the effect on whiting discards from using a 120 mm square mesh panel positioned at 6 metres from the codline. The results seem positive. In addition there are ongoing trials with flexible grids combined to cod selective devices and also large mesh "eliminator" style trawls. The data from this work has not yet been fully analysed but is encouraging. (France: Implications: Improvements in selectivity and reduction in cod catches).
- French vessels have been fully respecting the "real-time" closures in the North Sea introduced under the UK Conservation Credit Scheme. (France: Implications: Reduced cod catches).
- The use of sorting grids in trawl fisheries for Norway pout and Blue Whiting in the North Sea has become mandatory in the Norwegian sector in 2010. (Norway: Implications: Improved species selectivity).

Ecosystem effects

- Two Dutch vessels (TX68 and TX36) are using the pulse trawl under derogation but on a commercial basis. One vessels is using the pulse trawl and sum wing together. Results are promising and fuel savings up to 60% were achieved with good earnings. The system has shown to reduce catches of benthos by 50–70%, and likely reduce direct mortality of benthic invertebrates in the trawl path, 24% for the pulse trawl vs. 36% based on 15 taxa. Attempts are still being made by the Dutch ministry to enable allowance of

pulse trawling in the new European TCM regulation. (Netherlands: Implications: Replacement of beam trawl gear).

- Dutch beam trawlers are continuing to voluntarily use longitudinal release holes in the lower panel of the trawl, which open when nets are filled with benthos. This work was continued in 2009 but the industry felt that more research was needed over a longer period and also on commercial boats to further develop and fine-tune the techniques. (Netherlands: Implications: Reduced benthic impact).
- There is a suspected bycatch of harbour porpoise (*Phocoena phocoena* L.) in the Dutch gillnet fishery based on recent strandings. Autopsies showed that a number of deaths were likely fishery related. (Netherlands: Implications: cetacean bycatch).
- There is a suspected bycatch of cormorants and other diving birds in the Belgium gillnet fishery but the frequency with which it effectively happens is reportedly very low (Belgium: Implications Bycatch of seabirds).
- In the period 2009–2010 Belgium observed 15 trips on board a gillnetter. The fishing effort observed was 23153 km*h. No bycatches of marine mammals were observed. In total 24.600 km*h fishing effort was reported (net length times soaking time). The total marine mammal bycatch reported (by commercial fishers) consisted of 1 animal. (Belgium: Implications: Low bycatch of cetaceans in gillnet fisheries).
- Belgium beam trawlers are continuing to voluntary use "alternative" beam trawl, i.e. beam trawl with technical modifications (T90-codend, Benthos Release Panel, big meshes in the top panel). The initiative has been continuing since 2008. A better size and species selectivity is expected, as well as a discard reduction of benthic invertebrates. In addition the increasing use of the SumWing is supposed to reduce the impact on the seabed. (Belgium: Implications: Improved selectivity and reduced benthic impact).

Development of New Fisheries

- One Belgium otter trawler is targeting squid in area VIId as an alternative for winter. Several Belgian netters have carried out trials with gillnets for turbot, cuttlefish pots and fish traps, experiments were partially successful and will continue in 2010.

FTFB report to AFWG and NWWG

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Arctic Fisheries areas.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Norway solely.

Fleet Dynamics

- A restructuring scheme that permits allocation of quotas from 2–3 vessels to 1–2 units has been implemented in the Norwegian coastal fishing fleet. This allows the carrying capacity of individual fishing vessel to increase.

This scheme allows the same fishing platform to harvest pelagic and demersal fish resources. (Norway: Implications: Reductions in number of active vessels).

- An active process is ongoing to collect quota rights from 2–3 older fishing units to be used by a modern vessel with increased fishing capacity, or by new vessels. Older vessels are decommissioned or otherwise taken out of active fishing to accommodate such replacement vessels. (Norway: Implications: Modernisation of the fleet).
- There has been continued decline in fishing effort and total catch in the shrimp fisheries in the Barents Sea. Increased fuel cost is a driving force for the decline in shrimp trawl fisheries. (Norway: Implications: Reduction in effort).

Technical Creep

- In 2009 a semi-pelagic trawl technique for saithe was successfully developed and introduced in the Norwegian fishery. The most successful trawl is designed with hexagonal front part meshes and rigged with pelagic trawls off bottom. Better efficiency, less fuel consumption and reduced bottom impact are reported, but presently not quantified. (Norway: Implications: Increased fuel efficiency and lower bottom impact).
- Rigging of trawl doors off-bottom is becoming increasingly common among several traditional bottom-trawl fisheries in Norway (Trawling for Saithe, Norway Pout and Sandeel are included). (Norway: Implications: Reduce bottom impact).

Technical Conservation Measures

- A combined grid device that releases undersized fish and small shrimp is being developed in Norway and is being used voluntary by some vessels fishing shrimp in the Oslofjord. (Norway: Implications: Voluntary uptake of TCM device).

Ecosystem Effects

- The development of a pelagic trawl fishery for cod and other gadoids in the Barents Sea will reduce benthic impact significantly. Pelagic trawling is permitted for trawlers that have applied for such a licence. (Pelagic trawling is still illegal north of 65 deg. N. (Norway: Implications: Reduced bottom impact).

FTFB report to WGWIDE, HAWG, WGNEW and WGANSA

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in pelagic fisheries for horse mackerel, mackerel, anchovy, sardine, herring and blue whiting.

It should be noted that the information contained in this report does not cover fully all fleets engaged in pelagic fisheries; information was obtained from Ireland, Netherlands, UK-Scotland, England, Wales and Northern Ireland, Spain and Norway.

Fleet Dynamics

- The Norwegian fishery for blue whiting has reduced by 45% in the period 2008 – 2009. This has seen extra effort placed on other pelagic stocks. (Norway: Implications: Reduced effort on blue whiting).
- The anchovy Bay of Biscay (Subarea VIII) stock has suffered a strong decline since 2005 and the fishery remains close since 2007. Anchovy was the most important resource targeted by Spanish pelagic purse-seine fleet operating during spring in the Bay of Biscay. This Spanish fishery is strongly focused on the anchovy, due to its economic value, although there are other pelagic species available in spring seasons notably a strong seasonal (first four months of the year) fishery on spawning mackerel takes place in the east and central Subarea VIII. Northern Spanish coastal bottom Otter and Pair Trawl Fleets (OTB-PTB) target mackerel in this period. The closure of the anchovy fishery has forced purse-seiners to shift efforts into to spring mackerel fishery. The incorporation of the purse-seine fleet to the mackerel fishery and other factors (such as market demand, or SSB increasing) has led to a strong increase in the Spanish mackerel catches. To manage the quota, the Spanish government established a Ministerial Order from 2008 (Orders ARM/2091/2008 ARM/271/2010), in order to establish the criteria for the allocation and management of mackerel landings between different fisheries and fleets. This reallocation has led to a rapid depletion of the quota available for trawlers in 2010. As a consequence the fishery was closed in March 2010, the month with highest concentration of OTB-PTB trips targeting mackerel. (Spain: Implications: Shifts in effort to mackerel).
- In the Basque artisanal fleet fishing for tuna (trolling lines) and mackerel (handlines) all year, effort was restricted to 8–9 months in 2009 (about 3–4 month mackerel and 4–5 months tuna). Vessels stay in port for the rest of the year. The reduction of mackerel quota has restricted the fishery to 1–2 months and some boats have started fishing with other gears (longlines, gillnets) to supplement their fishing activities. (Spain: Implications: Shift in effort away from mackerel).
- Daily or weekly quotas (depending on the fishery) introduced by the fishers in the Basque mackerel fishery (handliners and purse-seiners) and in anchovy (purse-seiners). This can be considered like a market strategy trying to improve prices. (Spain: Introduction of voluntary management measures).
- The Celtic Sea herring fishery which had been planned to open in early January 2010 was abandoned except for a small-scale sentinel fishery. This was due to the large number of vessels that booked into the fishery as per the management arrangements in place. The local management committee deemed the fishery to be unviable with the number of vessels potentially wanting to fish. Arrangements for the fishery later in 2010 are under review. (Ireland: Implications: Closure of fishery).
- Four Irish RSW pelagic vessels are currently working three hundred miles off the coast of Chile and Peru fishing for sardinella. The vessels are landing directly into a mother ship. In addition two 38m RSW pelagic vessels form Castletownbere in southwest Ireland are fishing off Mauritania. These vessels are also landing to a mother ship. There is an increasing fo-

cus in developing third country opportunities for the Irish pelagic fleet as quotas for other species become tighter. (Ireland: Implications: Shift of effort from EU waters).

Ecosystem Effects

- It is expected that the inability of the bottom-trawler fleets to avoid catches of mackerel in the east and central Subarea VIII due to new management measures in place may result in increased discarding of this species. Preliminary analysis of data obtained from on-board observers after the exhaustion of the 2010 quota confirms this trend. (Spain: Implications: increased discarding).

Development of New Fisheries

- One 59m Irish RSW pelagic vessel has been chartered by a Chinese Company to carry out research on Peruvian squid and giant squid in the South Pacific. The Chinese company is endeavouring to develop a new fishery in international waters. (Ireland: Implications: Development of a new fishery).

FTFB report to WGECO, WGMME, SGBYC and WGNEW

Ecosystem Effects

- A number of fishers have reported very high levels of Anisakis worms being found in hake in the last 6–8 months. Counts as high as 17 per kg have been reported and this has resulted in a much lower price for hake. Changes to handling practices including holding the fish in slush ice prior to gutting and also gutting immediately on landing on deck have been tried to reduce the problem (Ireland: Implications: Parasitic worm problem).
- Predation of fish catches by mainly Grey seals form gillnet/tangle net fisheries continues to become a problem on all coasts of Ireland. Many inshore fishers have now stopped gillnetting as the level of damage is so high. Seals have been reported up to 80–90 miles off the coast. More than 30 vessels in the size range 10–20m are affected by this phenomenon. One vessel operating in Area VIa has reported that seals are not only targeting gillnets but also vessels jigging around wrecks and rough ground for white pollack. (Ireland: Implications: Unaccounted mortality caused by seal predation).
- Irish vessels fishing at Rockall (VIb) in Q1 and Q2 of 2010 report that haddock catches have reduced by 30–40% on previous years. There seems to be a scarcity of small haddock on the grounds and the vessels also report no Russian activity in international waters as in previous years. However, the vessels are reporting good signs of cod in the area, as well increased catches of monkfish and megrim. (Ireland: Implications: Reduction in haddock but increase in cod, monkfish and megrim).
- Irish vessels operating in VIa both inside and outside the restricted area (French Line) have reported very good signs of megrim and hake. They report catches at levels not seen since the 1990s. Catches seem to have increased along the shelf edge for these two species. Similarly 4–5 Irish gillnetters still in operation have enjoyed very good fishing for hake between

70 and 100 miles SW of the Mizen. Prices are poor but the large volumes (300–400 boxes for four hauls) are compensating for the bad price. (Ireland: Implications: Increased abundance of hake and megrim in VIa and VIIb-k).

- In VIa in 2010 Scottish vessels have reported poor monkfish catches and many areas seem to show unusually large numbers of Lesser Spotted Dogfish (*Scyliorhinus Canicula*) and Red (*Aspitrigla cuculus*) and Grey Gurnard (*Eutrigla gurnardus*). All Common Skate (Blue Skate, *Raja batis*) are now being discarded. There remains a tendency to "high grade" for species such as cod and hake as continued low quota and poor prices make it financially unattractive to land the smaller sizes. In addition to this unstable megrim prices in 2010, have also seen vessels discarding bruised Megrim. (Scotland: Implications Increased discarding/High-grading).
- There continues to be a reported cetacean bycatch in the French sea bass and Albacore tuna pair pelagic fisheries. This bycatch has reduced from peak levels but nonetheless still exists. Trials with a range of acoustic deterrent devices are continuing. (France: Implications: cetacean bycatch).
- Belgium beam trawlers are continuing to voluntary use "alternative" beam trawl, i.e. beam trawl with technical modifications (T90-codend, Benthos Release Panel, big meshes in the top panel). The initiative has been continuing since 2008. A better size and species selectivity is expected, as well as a discard reduction of benthic invertebrates. In addition the increasing use of the SumWing is supposed to reduce the impact on the seabed. (Belgium: Implications: Improved selectivity and reduced benthic impact).
- There is a lot of debate in the SW England on MPAs. Many fishers see access to grounds is most likely to be easier for static gear in future. This is a very dynamic situation and outline management plans are being drafted currently. Fishermen are fearful they will be put out of large areas. (UK: Implications: Development of MPAs with restricted fishing).
- Work is still ongoing in both the UK inshore and offshore static netting fisheries looking at the reduction of cetacean by catch. The Sea Mammal research Unit is carrying out trials with the 'DDD-super pinger' in the off shore fishery and the Cornwall wildlife trust is carrying out trials with the Aquatic pinger in the SW inshore fishery. Results are encouraging although there are issues still to be resolved with the reliability, range, safety, attachment and deployment within specific fisheries. (UK: Implications: Mitigation of cetacean bycatch).
- A new closure in the Hatton Bank in ICES Areas XIIb and VIb1 to protect cold-water corals has impacted on several Spanish deep-water trawlers. (Spain: Implications: Closure of area).
- As in other countries Basque fishers have begun experimenting with off-bottom-trawl doors, primarily to save fuel but with resulting reduction in bottom impact. (Spain: Implications: Reduced bottom impact).
- A number of Irish fishers have reported catching increasing quantities of small cod in shrimp pots. This is widespread over a large area of the south coast of Ireland. (Ireland: Implications: Abundance of small cod).
- There is widespread reporting of discarding of juvenile haddock in the Celtic Sea. Irish fishers have reported haddock in the size range from 20–23cm to be abundant on grounds on the south coast leading to widespread discarding. (Ireland: Implications: Discarding of small haddock).

- Irish inshore vessels have reported spurdog to be plentiful in Area VIa and VIIb in 2009 and 2010 contrary to scientific advice. Due to a zero quota for this species, however, they are forced to discard this species. (Ireland: Implications: Discarding of spurdog).
- The ratio of female to male *Nephrops* in the Porcupine Bank fishery according to fishers has changed markedly from being predominantly females in 2009 to more than 75% male in 2010. (Ireland: Implications: Unknown).
- Two Dutch vessels (TX68 and TX36) are using the pulse trawl under derogation but on a commercial basis. One vessels is using the pulse trawl and sum wing together. Results are promising and fuel savings up to 60% were achieved with good earnings. The system has shown to reduce catches of benthos by 50–70%, and likely reduce direct mortality of benthic invertebrates in the trawl path, 24% for the pulse trawl vs. 36% based on 15 taxa. Attempts are still being made by the Dutch ministry to enable allowance of pulse trawling in the new European TCM regulation. (Netherlands: Implications: Replacement of beam trawl gear).
- Dutch beam trawlers are continuing to voluntarily use longitudinal release holes in the lower panel of the trawl, which open when nets are filled with benthos. This work was continued in 2009 but the industry felt that more research was needed over a longer period and also on commercial boats to further develop and fine-tune the techniques. (Netherlands: Implications: Reduced benthic impact).
- There is a suspected bycatch of harbour porpoise (*Phocoena phocoena* L.) in the Dutch gillnet fishery based on recent strandings. Autopsies showed that a number of deaths were likely fishery related. (Netherlands: Implications: cetacean bycatch).
- There is a suspected bycatch of cormorants and other diving birds in the Belgium gillnet fishery but the frequency with which it effectively happens is reportedly very low (Belgium: Implications Bycatch of seabirds).
- In the period 2009–2010 Belgium observed 15 trips on board a gillnetter. The fishing effort observed was 23153 km*h. No bycatches of marine mammals were observed. In total 24.600 km*h fishing effort was reported (net length times soaking time). The total marine mammal bycatch reported (by commercial fishers) consisted of 1 animal. (Belgium: Implications: Low bycatch of cetaceans in gillnet fisheries).
- Belgium beam trawlers are continuing to voluntary use "alternative" beam trawl, i.e. beam trawl with technical modifications (T90-codend, Benthos Release Panel, big meshes in the top panel). The initiative has been continuing since 2008. A better size and species selectivity is expected, as well as a discard reduction of benthic invertebrates. In addition the increasing use of the SumWing is supposed to reduce the impact on the seabed. (Belgium: Implications: Improved selectivity and reduced benthic impact).
- The development of a pelagic trawl fishery for cod and other gadoids in the Barents Sea will reduce benthic impact significantly. Pelagic trawling is permitted for trawlers that have applied for such a licence. (Pelagic trawling is still illegal north of 65 deg. N. (Norway: Implications: Reduced bottom impact).
- Some Italian fishers in the central Adriatic Sea operating with demersal and pelagic trawl, on a voluntary basis have started to use pingers as de-

terrent for dolphin. They believe these devices will reduce predation and hence increase the efficiency of their gear. (Italy: Implications: Possible reduction in cetacean bycatch).

- The fleet of large Japanese bluefin surface longliners which visit Galway each autumn is not going to be such a feature in future years. As a result of falling demand, supply from fattening farms, high fuel costs, and reduced opportunities 64 of this fleet were decommissioned last March. (Japan: Implications: Reduction in effort on Bluefin Tuna).

FTFB report to GFCM

This report outlines a number of technical issues relating to fishing technology that may impact on fishing mortality and more general ecological impacts. This includes information recent changes in commercial fleet behaviour that may influence commercial cpue estimates; identification of recent technological advances (creep); ecosystem effects; and the development of new fisheries in the Mediterranean Sea.

It should be noted that the information contained in this report does not cover fully all fleets engaged in fisheries; information was obtained from Italy and a limited amount of information from France.

Fleet dynamics

- In the Mediterranean Sea, there has been a steady shift by French bottom trawlers from single rig trawling to twin trawling. (France: Implications: Unknown but possible increase in fishing effort).
- There has been an increase in the use of stone traps ("rock-grids") in Nephrops twin trawls used by the French fleet. As a consequence, rocks are spread in the fished area, increasing the risk of net damage for other trawlers. Also, this device makes possible the fishers to work on harder bottoms. (France: Implications: Changes to benthic habitats).
- From June 2010 in the Northern Adriatic sea the use of towed gears shall be prohibited within 3 nautical miles of the coast and also the use of beach-seine and boat seine targeting *Aphia minuta* (*Gobidae*) and juvenile sardine (*Sardina pilchardus*) shall be prohibited without any specific management plans in place. Many Italian vessels will be affected by these new regulations but the actual impacts in terms of fleet activity will not be known for some time. (Italy: Implications: Unknown shifts in effort).
- Since 2009 Italian bottom trawlers using twin trawls are obliged to tie-up one day in a week under national regulations. (Italy: Implications: Reduction in effort by twin-rig vessels).

Technical Creep

- In the last 3–4 years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishers: "Rete gemella"). The main characteristic of the twin-rig are four-panel trawls with small or large lateral panels (named Americana trawl, in Italian). These nets also have large meshes in the wing section and are manufactured in Raschel knotless-PA and knotted-PE netting. The nets are designed to have increased vertical and horizontal openings

are thought to be highly efficient. (Italy: Implications: More efficient trawls).

Technical Conservation Measures

- In order to reduce mortality rates for juveniles and discards of dying marine organisms by fishing vessels, Council Regulation (EC) No 1967/2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean, establishes that *"…from 1 July 2008, the net referred to in point 1* (that is "towed nets") *shall be replaced by a square-meshed net of 40 mm at the codend or, at the duly justified request of the shipowner, by a diamond meshed net of 50 mm"*. The Italian fishing fleet, however, will not accept the square mesh and will change the codend netting from 40 mm diamond to 50 mm diamond mesh instead. Less than 10–20% of the entire fleet has changed to the square mesh codend. It has been shown in trials carried out that the 50mm diamond mesh codend has poorer selection properties than the square mesh codend. (Italy: Implications: Poor selectivity).

Ecosystem Effects

- Some Italian fishers in the central Adriatic Sea operating with demersal and pelagic trawl, on a voluntary basis have started to use pingers as deterrent for dolphin. They believe these devices will reduce predation and hence increase the efficiency of their gear. (Italy: Implications: Possible reduction in cetacean bycatch).
- The fleet of large Japanese bluefin surface longliners which visit Galway each autumn is not going to be such a feature in future years. As a result of falling demand, supply from fattening farms, high fuel costs, and reduced opportunities 64 of this fleet were decommissioned last March. (Japan: Implications: Reduction in effort on Bluefin Tuna).

Annex 8: Summary Table of Seine Net Selectivity Experiments

COUNTRY	AREA	DATE	VESSEL LENGTH/HP	TYPE OF SEINE	METHOD	CATCH COMPARISON/ SELECTIVITY ANALYSIS	TEST DETAILS	REFERENCE
Ireland	Celtic Sea	1993	Caronia II 24m/550hp	Fly-dragging	Alternate Haul	Catch comparison	80mm x 4mm codendvs.80mm x 4mm codend + 80mm smp	Anon., 1993
Ireland	Celtic Sea	2000	Fiona Patricia 22m/650hp	Fly-dragging	Alternate Haul	Catch Comparison	80mm x 4mm codendvs.80mm x 4mm codend + 90mm smp	Anon., 2001
Ireland	Celtic Sea	2002	Comet 24m/425hp	Fly-dragging	Alternate Haul	Catch Comparison	80mm x 6mm codendvs.100mm x 4mm double/Experimental seine constructed in magnet twine (light twine)	Anon., 2002a
Ireland	Celtic Sea	2002	Honeydew 22m/600hp	Fly-dragging	Alternate Haul	Catch Comparison	80mm x 4mm singlevs.100mm x 4mm double	Anon., 2002b
Ireland	Celtic Sea	2004	Cisemair 23m/750hp	Fly-dragging	Alternate Haul	Selectivity Analysis	90mm x 6mm; 100mm x 6mm; 110mm x 6mm codends	Anon., 2005
Ireland	Celtic Sea	2005	Harmony 21m/475hp	Fly-dragging	Alternate Haul	Catch Comparison	90mm x 6mmvs.110mm x 6mm T90 codend	No report
Ireland	Celtic Sea	2005	Rosie Catriona 24m/550hp	Fly-dragging	Trouser seine	Catch Comparison	90mm x 6mm codendvs.100mm x 6mm codend; 90mm + 90mm smpvs.100mm; 100mmvs.100mm + 90mm smp	Anon., 2006
Scotland	North Sea	1985	Argosy	Fly-dragging	Covered codend	Selectivity	80mm, 90mm and 100mm codends.	Coull and Robertson, 1985
Scotland	North Sea	1990	Kestrel	Fly-dragging	Alternate Haul	Catch Comparison	90mm x 3mm codendvs.90mm x 3mm codend + 75mm smp	Arkley, 1990a
Scotland	North Sea	1990	Kestrel	Fly-dragging	Covered codend	Selectivity/Catch Compari Show Desktop.scf son	90mm x 3.5mm x 120 mesh circumferencevs.90mm x 3.5mm x 100 mesh circumferencevs.100mm x 100 mesh round circcumference	Arkley, 1990b

Country	Area	Date	Vessel length/hp	Type of Seine	Method	Catch comparison/ selectivity analysis	Test details	Reference
Scotland	North Sea	1991	Kilronan	Fly-dragging	Alternate Haul	Catch Comparison	90mm x 6mm codendvs.2 x 90mm smp (3.3m) placed at: Option 1. 10m above the codend Option 2. 7m above the codend Option 3. 6m above the codend Option 4. 5m above the codend Option 5. single smp at 5m above the codend	Ashcroft, 1991
Scotland	North Sea	2001	Harmony 23m/440hp	Fly-dragging	Alternate Haul	Selectivity Analysis	100mm x double 5mm codendvs.100mm + 90mm smp 3–6m; 100mm + 90mm smp 6–9m; 100mm + 90mm 9–12m	Anon., 2002b
Scotland	North Sea	2001	Jasper 26m/hp & Crystal River 26m/hp	Pair Seine	Paired Alternate Haul	Catch comparison	100mm x double 5mm codend with no cover bag+ 90mm smp 6–9m with 200 mesh extension vs 100mm x double 5mm codend with cover bag+ 90mm smp 9–12m with 500 mesh extension	Anon., 2002b
Canada	Southern Gulf of St Lawrence	1993	45ft class (200–212hp)	Fly-dragging	Trouser trawl	Selectivity analysis	Control codend: 55mm Selective codend: 130mm diamond 130mm square 145mm diamond 145mm square	Walsh and Winger, 2010
Canada	Southern Gulf of St Lawrence	1993	Prince Edouard Island	Fly-dragging	Alternate haul	Catch comparison	Control: footrope with double leads (4oz) attached with 18 inch (46cm) spacing with 4 inch (10cm) of slack Test: footrope with double leads attached with intervals of 24 inch (61cm) with 6 inch (15 cm) of slack	Walsh and Winger, 2010

COUNTRY	AREA	DATE	VESSEL LENGTH/HP	TYPE OF SEINE	METHOD	CATCH COMPARISON/ SELECTIVITY ANALYSIS	TEST DETAILS	REFERENCE
Canada			M.V. Mylene H 86.5ft, 565hp	Fly-dragging	Alternate haul	Catch comparison	Control : regular 155mm square and 175mm square codend Test : (1) topless 155 mm square mesh extention and codend (2) topless 155 mm square mesh extention and codend	Walsh and Winger 2010; Tait 1993.
Canada		1991	NA	Fly-dragging	Alternate haul	Catch comparison	130mm diamond 130mm square	Walsh and Winger 2010
Canada	Newfoundland south coast	1996	<65ft class	Fly-dragging	Alternate haul	Catch Comparison	145mm diamond codend 145mm square codend 159mm diamond codedn 159mm square codend	Walsh and Winger 2010
Canada	Newfoundland south coast	2000		Fly-drggaing	Alternate haul	Catch comparison	130mm diamond mesh codend 155mm diamond mesh codend 155mm square mesh codend	Walsh and Winger, 2010
Norway	Off Finnmarken coast	1986	60 ft/365hp	Fly-dragging	Alternate haul And Trouser trawl	Selectivity	120mm diamont mesh codend 120mm square codend	Isaksen and Larsen 1988
Norway	Off Finnmarken coast	1991	67ft / 47ft / 12ft	Fly-dragging	Covered codend + at surface collection	Selectivity	PAvs.PE in 135mm	Isaksen and Løkkeborg. 1993.
Iceland		1976		Fly-dragging		Selectivity	166mm	Thorsteinsson 1979 Hafrannsóknir
Australia	NSW	2000		Fly-dragging	Covered codend (including bunt and codend)	Selectivity	Panels of transparent mesh netting	Gray *et al.*, 2000
Denmark	Kattegat	1991	Doggerbank/517hp	Anchor Seine	Trouser Trawl	Selectivity	Codend mesh size	Poulsen and Wileman, 1991

COUNTRY	AREA	DATE	VESSEL LENGTH/HP	TYPE OF SEINE	METHOD	CATCH COMPARISON/ SELECTIVITY ANALYSIS	TEST DETAILS	REFERENCE
Denmark	Kattegat	1992	Doggerbank/517hp	Anchor seine	Covered codend	Selectivity	Codend mesh size/Square mesh panels	Moth-Poulsen *et al.*, 1992
Japan								
Japan								
US	South Gulf of Maine	2002	Coming Home	Fly-dragging	Observation only	Catch comparison	Raised footrope	Sheppard *et al.*, 2004

Annex 9: Summary of innovative projects

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
NL	SumWing	drag and fuel reduction	HFK Engineering	rising fuel costs	3	2008–2009	24	0.5	EU + national	x		x	x	x
NL	Cooperative Res	Organise groups of fishers to exchange information	Dutch ministry	unsustainability of beam trawling	?	2008-now	ongoing	0.5	EU + national		x			
FR	OPTIPECHE	energy saving and limited bottom impact	Brittany sea pole of competitiveness	environmental concerns. Fuel cost. Market and NGO pressure.	6	2007–2010	36	0.9	EU Brittany Regional Council Ifremer and private companies	x	x	x	x	x
USA	halibut excluder for GOA cod fishing	bycatch reduction	fishery	fishery limited by bycatch cap	Kodiak bottom trawlers and local gear manufacturer	2005–2007	3 years		Industry, government, catch allocation		x	x	x	
PL	T90 codend	improving selectivity for cod	Government	low Baltic cod stock	2	2004–2005	24		national		X	X	X	X
PL	T90 codend and extension	improving selectivity for cod	Government	low Baltic cod stock	2	2006–2007	24		national + EU		X	X		X

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
NL+	RECOVERY	Cod release	EU	low cod stock	8	2002–2005	38	3.0	EU + national	X	X	X	X	
NL+	NECESSITY	Discard reduction Nephrops & marine mammal bycatch	EU	discards in Neprops fisheries, bycatch marine mammals	23	2004–2007	38	8.2	EU + national	x	x	x	x	
NL+	DEGREE	Reduction bentic impact	EU	effects on benthic invertebrates	13	2006–2009	44	3.5	EU + national	x	x	x	x	x
NL+	ESIF	energy saving	EU	rising fuel costs	11	2008–2009	14	0.6	EU	x		x		x
NL	Pulse Trawl for flat fish	energy saving and lower seabed impact	Ministry	rising fuel costs and ecosystem efects of conventional beam trawling	2	1998-now	ongoing	x M€	national		X	X		
BE+	FLATNOSE (FISH 2007/07LOT3)	reducing discards in plaice and sole gears in North Sea	EU	low plaice and sole stocks	8	2008–2010			EU					
BE	Sumwing (developed by Dutch company)	Reduce fuel	Industry	Reduce fuel cons. & impact	fishing industry	2009–2010	24	0.0	Industry			x		

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
SE	Environmental friendly catch methods	Species selective trawls	Government	decreasing cod stock in Skagerrak and Kattegat	Fishery department, local fishers	2009–2010	Part of a 10 year project	k€	Government			x		
USA	salmon excluder	bycatch reduction	fishery	bycatch limitations on pollock fishery	pollock fishery and fishing gear manufacturers	2002-present	96		Industry, Government, catch allocation, North Pacific Research Board	x	x	x	x	x
USA	sweep modifications	reduce habitat impact and crab mortality (unobserved)	fishery	Threat of additional closures	Bering Sea bottom trawlers	2005 - present	6 years		Industry, Government, catch allocation, North Pacific Research Board		x	x	x	x
FR	ASCGG	Selectivity improvement in Nephrops fishery in Bay of Biscay	National Fisheries Committee	decrease hake and Nephrops discards. Hake restoration plan.	Fishermen Committees. Ifremer	2002–2004	24		EU. State. Regional Councils (Bretagne, Pays de Loire, Poitou-Charentes)	x	x	x	x	x

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
FR	NECESSITY Cetaceans sub-project	Discard reduction Nephrops & marine mammal bycatch	EU	discards in Neprops fisheries, bycatch marine mammals	23	2004–2007	36	0.9	EU	x	x	x	x	x
FR	DEGREE	To develop new gears/fishing techniques that have a lower impact on benthic habitats	EU	Request from EU, Environmental concerns.	Ifremer, Morgère Company	2006–2009	3 years	0.4	EU	X	X		X	X
NL, BE	VDTN	reducing discards	Product board	discards	3	2008-now	48	0.3	national		x			
BE	Hovercran, pulse trawl for brown shrimps	Reduce seabed contact and discards	Initiative ILVO	Impact of shrimp fishery	Marelec, fishing industry	2007 - xxxx	ongoing	0.4	Flemish government and EU	x	x	x	x	
BE	Alternative beam trawl	Reduce discards	Initiative ILVO	Impact of flatfish fishery	fishing industry	2004 - xxxx	ongoing	0.5	Flemish government and EU	x	x	x	x	

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	FLUME TANK MODEL STUDIES	SEA TRIALS ON RESEARCH VESSELS	SEA TRIALS ON COMMERCIAL VESSELS	UNDERWATER OBSERVATION (VIDEO)	GEAR MEASUREMENTS
FR	NECESSITY Nephrops sub-project	Discard reduction Nephrops & marine mammal bycatch	EU	discards in Neprops fisheries, bycatch marine mammals	23	2004–2007	36	880 K€	EU Ifremer	x	x		x	x
BE	Outrigger	Alternative for beam trawl	Industry	Reduce fuel cons.	fishing industry	2007–2008	24	0.4	Flemish government and EU			x		x
BE	Passive fishing	Introduce passive fishing methods	Initiative ILVO	Reduce fuel cons.	fishing industry	2004 - xxxx		0.6	Flemish government and EU	x		x		
NL, BE	Outriggen 2008	higher sole catches	skippers	rising fuel costs	4	2008–2009	24	0.5	EU + national				x	x
NL	HydroRig	water flow stimulation	skipper	rising fuel costs	4	2008-now	ongoing	0.5	EU + national	x		x	x	x
NL	Passive Gears	year-round passive gear operation		rising fuel costs	6	2010-now	ongoing	0.1	EU + national			x		
TUR	investigations to improve species and size selectivity in mersin bay trawl fisheries	improving selectivity	University	Realising lack of information on this fishery and wish to be useful.	Mersin, Çukurova and Middle east technical university.	2010–2013	36	0.175	Turkish Scientific and Technical Research Council	-	x	x	x	not to start with
NL	ViBOS	decision support system		rising fuel costs	5	2010-now	ongoing	0.5	EU + national			x		x

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
PL	T90 trawl	improving selectivity for cod	Government	low Baltic cod stock	?	2006–2007; 2008-now	24; ongoing		national + EU		x	x		x
FR	SPD	to develop and/or test new selective devices in the Nephrops fishery in Bay of Biscay.	AGLIA (Association du Grand Littoral Atlantique), acting as an interface between fishers and scientists + Ifremer	Decrease more significantly fish and Nephrops discards. Request from National Fisheries Authority. Market and NGO pressure.	AGLIA. Ifremer. All concerned local Fishermen Committees	2009–2011	24		State EU Regional councils Ifremer	x	x	x	x	x
NL	Industry surveys	own survey results next to gov surveys	industry	doubts on scientific survey results	3	2009-now	ongoing	0.5	EU + national		x	x		
ES	PSE_REDES	improve selectivity and reduce discarding	Instituto Español de Oceanografía	High Discard rates in some Spanish Fisheries and lack of R & D in selectivity technology	4	2009–2013	48	1,307,646 (2009–2010)	Spanish Science and Innovation Ministry and the UE	x		x	x	x
FR	ITIS SQUAL	fish pots and Nephrops traps	Brittany sea pole of competitiveness	Environmental concerns. Fuel cost. Market and NGO pressure.	5	2007–2010	3 years	0.87	State Ifremer and private companies.	x	x	x	x	x

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
FR	SELECMER	to reduce whiting discards by 30% in the southern North Sea and in the eastern area of the Channel	French Fisheries Authority (DPMA)	to comply with an agreement with Norway.	Regional Fisheries Committee in Nord Pas de Calais-Picardie	2008–2009	18	0.08 (Ifremer only)	Fisheries Authority (DPMA). EU	x		x	x	x
FR	SELECCAB	to reduce significantly cod discards in the southern North Sea and in the eastern area of the Channel	French Fisheries Authority (DPMA)	to comply with an agreement with Norway. Low cod stock	National fishers committee. Regional Fishermen Committee in Nord Pas de Calais-Picardie	2009–2010	18	0.08 (Ifremer only)	Fisheries Authority (DPMA). EU	x		x	x	x
FR	PRESPO	multidisciplinary project aiming to collect biological, social, economical, environmental data for sustainable management of artisanal fisheries: information management and reducing discards	Interreg call	Improve data collection. High discard rates in the participating countries.	9	2009–2011	36	6.67	UE all partners	x	x	x	x	x

State	Project Acronym	Topic(s) or objectives	Initial request from whom?	Drivers for this request	Partners	Period	Duration (months)	Budget indication (M €)	Who financed ?	Flume tank model studies	Sea trials on research vessels	Sea trials on commercial vessels	Underwater observation (video)	Gear measurements
FR	CHAMAD	improve selectivity and decrease fuel consumption in shrimp trawls	GAPCM Shrimp fishers organization	High fish discards rate. Fuel cost. Complying with US regulation on shrimp importation (implementation of TEDs)	GAPCM Shrimp fishers organization	2004–2006	36		GAPCM funded by AFD French Agency for Development	x		x		x
FR	EFFICHALUT	energy savings in bottom trawling in the southern North Sea and in the eastern area of the Channel	Call from French Fisheries Authority (DPMA). CME (Fishermen cooperative)	Fuel cost in bottom trawling	CME (Fishermen cooperative)	2009–2010	18		Fisheries Authority (DPMA)	x		x		x

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
NL	SumWing	in budget	project meetings	website, articles, presentations, reports, flyers	Various SumWings	50 sold	5	Works even better with pulse trawling system built in. Savings upto 60% in fuel. Application for rougher fishing grounds under development.
NL	Cooperative Res	in budget	project meetings	website, articles, presentations, reports, flyers	forum to discuss problems in specific fisheries, reports	13 existing groups	5	Good reception by industry
FR	OPTIPECHE	Y	Steering committees	DVD on the project. Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conference presentations.	Optimised trawls (5 to 17% decrease of fuel consumption); 1 new commercial trawl door (lower impact and fuel consumption)	A lot of improvements on-board fishing vessels (larger meshes, thinner twines, etc.). One new trawl door on the market.	5	A lot of improvements on-board fishing vessels and a very efficient low impacting and consuming trawl door
USA	halibut excluder for GOA cod fishing	catch allocation or charter		one council presentation	reduction in halibut bycatch during fall cod fishery	design in use by fleet during that period by mutual agreement	4.5	A fleet of about 10–12 vessels agreed to working with the device when bycatches are high
PL	T90 codend	Y	project meetings	flyers, meetings with fishers, presentations, reports, papers	Selective codend	Used in commercial fisheries	4.5	Introduced in EU regulation and enforcement in Baltic cod fishery
PL	T90 codend and extension	N	project meetings	flyers, meetings with fishers, presentations, reports, papers	Selective codend	Used in commercial fisheries	4.5	Introduced in EU regulation and enforcement in Baltic cod fishery

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
NL+	RECOVERY	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	selective gear devices	available for uptake	4	No real uptake of e.g. LMT in beam trawl NL, devices in white fish and Nephrops trawls are being further developed.
NL+	NECESSITY	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	selective gear devices	available for uptake	4	A range of selective Nephrops trawls were designed. Good start on multidisciplinary work showing advantages of more selective gears. Work on marine mammals showed some potential for pinger use in pelagic nets.
NL+	DEGREE	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	lower impact gear devices	available for uptake	4	Good start on multidisciplinary work showing advantages of lower seabed impact gears.
NL+	ESIF	N	project meetings	articles, presentations, publications	report	available	4	Net profits hard to achieve under most scenarios, savings in fuel can be substantial: 5–50%
NL	Pulse Trawl for flat fish	Y	project meetings	articles, presentations, reports	prototypes 7m and 12m	available for trials, but blocked by EU-ban	4	Method proven to lower benthic bycatch and seabed effects. Can be run economically. Still under debate by ICES (WKPULSE). Further ecosystem effect studies needed. Integration with SumWing seems to work well. EU-ban should be lifted or derogation assured. Two vessels are using pulse trawls now under derogation.

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
BE+	FLATNOSE (FISH 2007/07LOT3)	N	project meetings	articles, presentations, publications	report	in preparation	4	Predictions were calculated based on the model of Piet *et al*., 2009 on landings and discards in a range of métiers of gear where plaice and sole catches play a role. The effects of alternative gears (pulse trawl, outriggers, static nets, combinations thereof) were studied.
BE	Sumwing (developed by Dutch company)	Y			new gear	In use in industry	4	Used by 12 large beam trawlers
SE	Environmental friendly catch methods	Paid by day during sea trails	Seminars	Seminars	Grid	Step 1 out on the market	4	First step finished and used by most fishers, second step the first successful sea trials have been carried out
USA	salmon excluder	catch allocation or charter	periodic workshops as results available and decisions needed	presentations at management council meetings, workshops open	design for excluder with measured effectiveness	common use in fishery - more expected with bycatch limitations	4	Widely used in the fleet in high bycatch situations
USA	sweep modifications	catch allocation or charter	periodic workshops as results available and decisions needed	presentations at management council meetings, workshops open	sweep modifications with measures of impact reductions and maintenance of catch rates	schedule mandate in January 2011	4	Required for the entire fleet, 12–15 large high production vessels.

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
FR	ASCGG	NA	Steering Committee. Information letter. Videos produced by Ifremer	TV programmes. Conferences. Brochure at the end of the project. Articles in newspapers.	Hake SMP (100mm) on the top of the extension piece First flexible Nephrops grid	SMP mandatory.	4	SMP accepted and proposed for EU regulation by the fishers. Nephrops grid still not used due to its short shelf life in rocky areas but on going project (see SPD) with a new rigging solving all technical problems (no more contact on the bottom).
FR	NECESSITY Cetaceans sub-project	Y	Steering Committee. Project meetings. Workshop at Ifremer flume tanks	DVD of the project. DVD on Cetaceans trials (produced by the Local Fishermen Committee of La Turballe). Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conferences in professionnal exhibitions (ITECH'MER Lorient)	Different exclusion devices (grid, net barriers) Directional acoustic deterrent (CETASAVER).	Directional acoustic deterrent on the market	4	Pinger efficient, but not yet mandatory. Still under test.
FR	DEGREE	_	Project meetings	Few as development of doors confidential	1 prototype of trawl door (very low impact and lower fuel consumption).	Prototype to industrialize	4	Innovative door prototype ('jumper' door) should be inntroduced in the commercial fishery in the coming year.
NL, BE	VDTN	N	project meetings	articles, presentations, reports	prototype gear devices	Further tests needed for commercial uptake	3	Some devices developed that work well in releasing benthos without too large a target species loss. Further development on commercial boats needed.

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
BE	Hovercran, pulse trawl for brown shrimps	NA	?	?	Hovercran gear prototype	Ready for commercial application	3	Prototype effective in catching shrimp, but further development is needed. Awaiting finances for commercial introduction. Interest shown by the industry.
BE	Alternative beam trawl	Y			Combination of selective devices	Ready for commercial application	3	Some devices are being used (e.g. wheel shoes, T90), some skippers took up BRPs and are trying these out. Project also on improving image. In LMT Dyneema is used. ISP not used any more, was intended to release cod.
FR	NECESSITY Nephrops sub-project	_	Steering Committee. Project meetings. Workshop at Ifremer flume tanks	DVD on the project. Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conference presentations.	Selective devices for Nephrops trawls. Assessment of the impact of the devices on Nephrops and hake stocks and landings.	Combination of Nephrops grid and SMP on the top of the extension piece in the regulation	3	Need to improve the shelvelife of the grid in rocky areas (see SPD project in 2009–2010). Other devices tested later (using the results coming from NECESSITY project)
BE	Outrigger	Y			new gear	In use in industry	3	Used seasonally by some vessels
BE	Passive fishing	Y			new vessels	In use in industry	3	Uptake by 4 new vessels in fleet of 90 vessels dominated by beam trawl
NL, BE	Outriggen 2008	in budget	project meetings	website, articles, presentations, reports, flyers	outrig gears	can be used, but need improvement	2	Not effective to catch sole, discard rates still too high, good fuel saving technique. One boat stopped using outrigger, the other continued. Further development needed.

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
NL	HydroRig	in budget	project meetings	website, articles, presentations, reports, flyers	prototypes	can be used, but need improvement	2	Worked relatively well on plaice with cups below beam, on headline less effective? Crew asked to stop momentarily. Further work needed.
NL	Passive Gears	in budget	project meetings	website, articles, presentations, reports, flyers	none yet	starting phase	1	Slow start, 3 boats are experimenting with passive gears.
TUR	investigations to improve species and size selectivity in mersin bay trawl fisheries	Vessel hire	Meetings	Meetings, workshops, video presentation	Selective devices	not tested yet	1	Selective designs will be formed by evaluating the data from the first two work packages of the project, literature information, and opinion and criticisms by experienced fishers.
NL	ViBOS	in budget	project meetings	website, articles, presentations, reports, flyers	none yet	starting phase	0	Slow start, due to financing problems of the leading company.
PL	T90 trawl	N	project meetings	not yet	not yet	not yet	0	n/a
FR	SPD	Y	Steering Committee. Information letter. Reports. Submarine videos produced by Ifremer	Innovation conference in Lorient in June 2010.	SM cylinder New Nephrops grid and new rigging (solving all technical previous problems). Combination SM cylinder and new Nephrops grid	in progress	in progress	
NL	Industry surveys	in budget	project meetings	website, articles, presentations, reports, flyers	reports	uptake		Creates more mutual understanding

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
ES	PSE_REDES	Y	Y	Y	Gears, selective devices, analytical tools, links between stakeholders	NA		No assessment of success (recent launch, not finished)
FR	ITIS SQUAL	N	Steering committees. Workshops with the fishers	Meetings with all stakeholders. Articles in professional newspapers. Conferences in professional exhibitions (ITECH'MER Lorient). Presentations at the Brittany sea pole of competitiveness	New concepts of foldable fish pots	5 new types of fish pots produced by Le Drezen Company	4	Catchability trials already done but a lot to do to experiment these pots all along the French seashore. Foldable prototype of Nephrops traps to improve
FR	SELECMER	Y	Steering Committee. Workshop at flume tank Reports	Reports. Specialised newspapers.	Whiting flexible grid.	to be improved in SELECAB project	3	escapement rate of 30% of the small whiting below 22cm and 50% of plaices below 27cm. Nevertheless, these results have to be improved to optimize whiting escapement up to the legal size of 27cm
FR	SELECCAB	Y	Steering Committee. Workshop at flume tank Reports	Reports. Specialised newspapers.	Whiting flexible grid combined to square mesh panel. Cod grid. Large meshes trawl	in progress	in progress	

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
FR	PRESPO	Y	Steering Committee. Reports	Flyers Posters	Test of T90 codend in Nephrops fishery in the bay of Biscay. On going trials on Nephrops survival.	in progress	in progress	
FR	CHAMAD	Y	Reports. Workshop at flume tank	-	Implementation of TEDs and BRD (Square mesh panels). Optimised shrimp trawl for lower fuel consumption	implemented	5	
FR	EFFICHALUT	Y	Steering Committee. Workshop at flume tank. Reports	Reports. Specialised newspapers.	Optimised trawls . In progress	in progress	in progress	
State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
NL	SumWing	in budget	project meetings	website, articles, presentations, reports, flyers	Various SumWings	50 sold	5	Works even better with pulse trawling system built in. Savings upto 60% in fuel. Application for rougher fishing grounds under development.

State	Project Acronym	Financial compensation for fishers's input	Internal project communication	Communication with the outside world	Products (new gears, selective devices, new gear components)	State (mandatory, in progress, on the market, etc.)	Rate of success ? 0=no uptake; 5=full uptake	Comments on success or uptake
NL	Cooperative Res	in budget	project meetings	website, articles, presentations, reports, flyers	forum to discuss problems in specific fisheries, reports	13 existing groups	5	Good reception by industry
FR	OPTIPECHE	Y	Steering committees	DVD on the project. Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conference presentations.	Optimised trawls (5 to 17% decrease of fuel consumption); 1 new commercial trawl door (lower impact and fuel consumption)	A lot of improvements on-board fishing vessels (larger meshes, thinner twines, etc.). One new trawl door on the market.	5	A lot of improvements on board fishing vessels and a very efficient low impacting and consuming trawl door
USA	halibut excluder for GOA cod fishing	catch allocation or charter		one council presentation	reduction in halibut bycatch during fall cod fishery	design in use by fleet during that period by mutual agreement	4.5	A fleet of about 10–12 vessels agreed to working with the device when bycatches are high
PL	T90 codend	Y	project meetings	flyers, meetings with fishers, presentations, reports, papers	Selective codend	Used in commercial fisheries	4.5	Introduced in EU regulation and enforcement in Baltic cod fishery
PL	T90 codend and extension	N	project meetings	flyers, meetings with fishers, presentations, reports, papers	Selective codend	Used in commercial fisheries	4.5	Introduced in EU regulation and enforcement in Baltic cod fishery
NL+	RECOVERY	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	selective gear devices	available for uptake	4	No real uptake of e.g. LMT in beam trawl NL, devices in white fish and Nephrops trawls are being further developed.

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NL+	NECESSITY	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	selective gear devices	available for uptake	4	A range of selective Nephrops trawls were designed. Good start on multidisciplinary work showing advantages of more selective gears. Work on marine mammals showed some potential for pinger use in pelagic nets.
NL+	DEGREE	in budget	project meetings, website	website, liaison groups, articles, presentations, publications	lower impact gear devices	available for uptake	4	Good start on multidisciplinary work showing advantages of lower seabed impact gears.
NL+	ESIF	N	project meetings	articles, presentations, publications	report	available	4	Net profits hard to achieve under most scenarios, savings in fuel can be substantial: 5–50%
NL	Pulse Trawl for flat fish	Y	project meetings	articles, presentations, reports	prototypes 7m and 12m	available for trials, but blocked by EU-ban	4	Method proven to lower benthic bycatch and seabed effects. Can be run economically. Still under debate by ICES (WKPULSE). Further ecosystem effect studies needed. Integration with SumWing seems to work well. EU-ban should be lifted or derogation assured. Two vessels are using pulse trawls now under derogation.
BE+	FLATNOSE (FISH 2007/07LOT3)	N	project meetings	articles, presentations, publications	report	in preparation	4	Predictions were calculated based on the model of Piet *et al*., 2009 on landings and discards in a range of métiers of gear where plaice and sole catches play a role. The effects of alternative gears (pulse trawl, outriggers, static nets, combinations thereof) were studied.

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BE	Sumwing (developed by Dutch company)	Y			new gear	In use in industry	4	Used by 12 large beam trawlers
SE	Environmental friendly catch methods	Paid by day during sea trails	Seminars	Seminars	Grid	Step 1 out on the market	4	First step finished and used by most fishers, second step the first successful sea trials have been carried out
USA	salmon excluder	catch allocation or charter	periodic workshops as results available and decisions needed	presentations at management council meetings, workshops open	design for excluder with measured effectiveness	common use in fishery - more expected with bycatch limitations	4	Widely used in the fleet in high bycatch situations
USA	sweep modifications	catch allocation or charter	periodic workshops as results available and decisions needed	presentations at management council meetings, workshops open	sweep modifications with measures of impact reductions and maintenance of catch rates	schedule mandate in January 2011	4	Required for the entire fleet, 12–15 large high production vessels.
FR	ASCGG	NA	Steering Committee. Information letter. Videos produced by Ifremer	TV programmes. Conferences. Brochure at the end of the project. Articles in newspapers.	Hake SMP (100mm) on the top of the extension piece First flexible Nephrops grid	SMP mandatory.	4	SMP accepted and proposed for EU regulation by the fishers. Nephrops grid still not used due to its short shelf life in rocky areas but on going project (see SPD) with a new rigging solving all technical problems (no more contact on the bottom).

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FR	NECESSITY Cetaceans sub-project	Y	Steering Committee. Project meetings. Workshop at Ifremer flume tanks	DVD of the project. DVD on Cetaceans trials (produced by the Local Fishermen Committee of La Turballe). Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conferences in professionnal exhibitions (ITECH'MER Lorient)	Different exclusion devices (grid, net barriers) Directional acoustic deterrent (CETASAVER).	Directional acoustic deterrent on the market	4	Pinger efficient, but not yet mandatory. Still under test.
FR	DEGREE	_	Project meetings	Few as development of doors confidential	1 prototype of trawl door (very low impact and lower fuel consumption).	Prototype to industrialize	4	Innovative door prototype ('jumper' door) should be inntroduced in the commercial fishery in the coming year.
NL, BE	VDTN	N	project meetings	articles, presentations, reports	prototype gear devices	Further tests needed for commercial uptake	3	Some devices developed that work well in releasing benthos without too large a target species loss. Further development on commercial boats needed.
BE	Hovercran, pulse trawl for brown shrimps	NA	?	?	Hovercran gear prototype	Ready for commercial application	3	Prototype effective in catching shrimp, but further development is needed. Awaiting finances for commercial introduction. Interest shown by the industry.

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BE	Alternative beam trawl	Y			Combination of selective devices	Ready for commercial application	3	Some devices are being used (e.g. wheel shoes, T90), some skippers took up BRPs and are trying these out. Project also on improving image. In LMT Dyneema is used. ISP not used any more, was intended to release cod.
FR	NECESSITY Nephrops sub-project	_	Steering Committee. Project meetings. Workshop at Ifremer flume tanks	DVD on the project. Submarine videos produced by Ifremer. TV programmes. Articles in professional newspapers. Conference presentations.	Selective devices for Nephrops trawls. Assessment of the impact of the devices on Nephrops and hake stocks and landings.	Combination of Nephrops grid and SMP on the top of the extension piece in the regulation	3	Need to improve the shelvelife of the grid in rocky areas (see SPD project in 2009–2010). Other devices tested later (using the results coming from NECESSITY project)
BE	Outrigger	Y			new gear	In use in industry	3	Used seasonally by some vessels
BE	Passive fishing	Y			new vessels	In use in industry	3	Uptake by 4 new vessels in fleet of 90 vessels dominated by beam trawl
NL, BE	Outriggen 2008	in budget	project meetings	website, articles, presentations, reports, flyers	outrig gears	can be used, but need improvement	2	Not effective to catch sole, discard rates still too high, good fuel saving technique. One boat stopped using outrigger, the other continued. Further development needed.
NL	HydroRig	in budget	project meetings	website, articles, presentations, reports, flyers	prototypes	can be used, but need improvement	2	Worked relatively well on plaice with cups below beam, on headline less effective? Crew asked to stop momentarily. Further work needed.

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NL	Passive Gears	in budget	project meetings	website, articles, presentations, reports, flyers	none yet	starting phase	1	Slow start, 3 boats are experimenting with passive gears.
TUR	investigations to improve species and size selectivity in mersin bay trawl fisheries	Vessel hire	Meetings	Meetings, workshops, video presentation	Selective devices	not tested yet	1	Selective designs will be formed by evaluating the data from the first two work packages of the project, literature information, and opinion and criticisms by experienced fishers.
NL	ViBOS	in budget	project meetings	website, articles, presentations, reports, flyers	none yet	starting phase	0	Slow start, due to financing problems of the leading company.
PL	T90 trawl	N	project meetings	not yet	not yet	not yet	0	n/a
FR	SPD	Y	Steering Committee. Information letter. Reports. Submarine videos produced by Ifremer	Innovation conference in Lorient in June 2010.	SM cylinder New Nephrops grid and new rigging (solving all technical previous problems). Combination SM cylinder and new Nephrops grid	in progress	in progress	
NL	Industry surveys	in budget	project meetings	website, articles, presentations, reports, flyers	reports	uptake		Creates more mutual understanding
ES	PSE_REDES	Y	Y	Y	Gears, selective devices, analytical tools, links between stakeholders	NA		No assessment of success (recent launch, not finished)

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FR	ITIS SQUAL	N	Steering committees. Workshops with the fishers	Meetings with all stakeholders. Articles in professional newspapers. Conferences in professional exhibitions (ITECH'MER Lorient). Presentations at the Brittany sea pole of competitiveness	New concepts of foldable fish pots	5 new types of fish pots produced by Le Drezen Company	4	Catchability trials already done but a lot to do to experiment these pots all along the French seashore. Foldable prototype of Nephrops traps to improve
FR	SELECMER	Y	Steering Committee. Workshop at flume tank Reports	Reports. Specialised newspapers.	Whiting flexible grid.	to be improved in SELECAB project	3	escapement rate of 30% of the small whiting below 22cm and 50% of plaices below 27cm. Nevertheless, these results have to be improved to optimize whiting escapement up to the legal size of 27cm
FR	SELECCAB	Y	Steering Committee. Workshop at flume tank Reports	Reports. Specialised newspapers.	Whiting flexible grid combined to square mesh panel. Cod grid. Large meshes trawl	in progress	in progress	
FR	PRESPO	Y	Steering Committee. Reports	Flyers Posters	Test of T90 codend in Nephrops fishery in the bay of Biscay. On going trials on Nephrops survival.	in progress	in progress	

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FR	CHAMAD	Y	Reports. Workshop at flume tank	-	Implementation of TEDs and BRD (Square mesh panels). Optimised shrimp trawl for lower fuel consumption	implemented	5	
FR	EFFICHALUT	Y	Steering Committee. Workshop at flume tank. Reports	Reports. Specialised newspapers.	Optimised trawls . In progress	in progress	in progress	

Annex 10: Available instrumentation and instrumentation currently used by gear technologists to measure the impacts of GBTMs

ECOSYSTEM COMPONENT	IMPACT	METHODOLOGIES/INSTRUMENTATION
Habitats	resuspension of sediment	
	a) physical effects	particale analysers (LOPC, LISST)
		turbidity meters (backscatter, transmissionmeter)
		sediment traps
		sediment profile imaging (SPI)
		acoustic methods (multibeam, sidescan, vertical sounder)
		modelling
	b) chemical effects	water analysis (e.g. nutrients, pollutants, O2/H2SO4)
		sediment profile imaging (SPI) with chemical markers
		Coring
		meso-cosm analsyses/experiments
	c) biological effects	sediment profile imaging (SPI) with chemical markers
		Coring
		meso-cosm analsyses/experiments
		water sampling (counting of cop-eggs, dynoflygellates etc.)
	bottom topography (penetration, trawlpath, displacement)	acoustic methods (multibeam, sidescan)
		imaging (laser line, stereoimaging, video)
		direct observation (divers)
	bottom structure (sediment stratification)	benthic corers
		sediment profile imaging (SPI)
		acoustic methods (vertical sounder)
	pressure excerted to bottom	pressure sensors
Fish, cephalopods and benthos	catch mortality incl, unaccounted mortality	
	a) landings	catch sampling
	b) discards	catch sampling, discard sampling
		survival studies (tanks, reflex index)
		selectivity studies (twin trawl method, codend cover, alternate hauls, Parallel hauls)
		Flume tank
		Modelling
	c) escapes	survival studies (tanks, reflex index)
		Escapes
		cover codends

ECOSYSTEM COMPONENT	IMPACT	METHODOLOGIES/INSTRUMENTATION
		direct observations
	d) trawlpath mortality	direct observation
		survival studies (capture/sammple net, reflex index)
		benthic sampling
		Coring
Mammals, reptiles and birds		catch sampling/discard sampling
		CCTV
		acoustic detection devices e.g. DIDSON
		optical methods
		direct observation (divers)