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18–22 May 2009

Ancona, Italy

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International Council for the Exploration of the Sea
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Contents

Executive summary **5**

1 Directive **9**

2 Introduction **9**

2.1 Terms of Reference 9

2.2 Participants 10

2.3 Explanatory note on meeting and report structure 10

3 WGFTFB advice and requests during 2008/2009 ..... **11**

3.1 Overview 11

4 Report from theStudy Group on the Development of Fish Pots for Commercial Fisheries and Survey Purposes (SGPOT) **12**

5 Report from the Study Group on combining gear parameters into effort and capacity metrics (SGEM) **13**

6 Update on electric beam trawl work **14**

7 Update on Gear Classification Topic **15**

8 WGECO request on gear efficacy framework **16**

9 ToR a) Advice to assessment WGs **20**

9.1 General Overview 20

9.2 Terms of Reference 20

9.3 General issues 21

9.4 Information for individual assessment working groups 29

9.5 Recommendations 29

10 ToR b) Seine net fisheries **30**

10.1 General Overview 30

10.2 Terms of Reference 31

10.3 List of Participants 31

10.4 General issues 31

10.4.1 Identification of seine net fisheries 31

10.4.2 Scottish Seining (Fly-dragging) 33

10.4.3 Danish Anchor Seine 33

10.4.4 Pair Seine 33

10.5 Assessment of Seine Net Fisheries 34

10.5.1 Fuel Efficiency 34

10.5.2 Environmental Impact 36

10.5.3 Fish Quality 37

10.5.4 Selectivity/Discarding 38

10.5.5 Technology Creep 39

10.6 Conclusions 42
10.7 Recommendations 43
10.8 References 43
10.9 Individual Presentation 45
10.9.1 Review of Seine Net Seminar held in Iceland 2008 45

11 ToR c) Discard policy and framework 45
11.1 General Overview 45
11.2 Terms of Reference 46
11.3 General Issues 46

12 ToR d) Technical issues relating to the Mediterranean 48
12.1 General overview and presentation of main findings 48
12.2 Terms of Reference 48
12.3 List of Participants 48
12.4 Overview 49
12.4.1 Review new research with 40 mm square-mesh codends recently introduced into EU legislation for the Mediterranean 49
12.4.2 Assess the efficacy of 40mm square-mesh codends in terms of improved selectivity and fish survival 50
12.4.3 Identify whether from a technical perspective that the regulation needs to be amended 50
12.5 Discussion and conclusions 51
12.5.1 Review new research with 40 mm square-mesh codends recently introduced into EU legislation for the Mediterranean 51
12.5.2 Assess the efficacy of 40 mm square-mesh codends in terms of improved selectivity and fish survival. 51
12.5.3 Identify whether from a technical perspective that the regulation needs to be amended. 52
12.6 Recommendations 52
12.6.1 Selected publications related to trawl selectivity in Mediterranean. 53
12.7 Abstracts of the Presentations 54
12.7.1 EC Reg. 1967/2006: is square-mesh better selective than larger mesh-size? Comparative experiments in Sicilian trawl fisheries 54
12.7.2 Preliminary data on survival of Norway lobster (*Nephrops norvegicus*) escaping through standard diamond and square mesh codends 54
12.7.3 Size selectivity of diamond (PA) and square (PE) mesh codends for commercially important fish species in the Antalya Bay, eastern Mediterranean 54

12.7.4 Effectiveness of a sorting grid on fish separation and size selectivity for the deepwater rose shrimp in Turkish bottom trawl fisheries 55

12.8 Abstracts of Posters 55

12.8.1 Norwegian hooks in the Adriatic longline fishery: a pilot study 55

12.8.2 Selectivity of 50 mm diamond and 40 mm square-mesh codend for five commercially important species in the Eastern Mediterranean 56

12.8.3 Blanket net fishery in Aegean Sea 56

12.8.4 Reducing non-target species in trammel net fishery on sea grass (*Posidonia oceanica*) meadows 57

12.8.5 Selectivity of diamond and square mesh PA codends for European hake (*Merluccius merluccius*) in the Sea of Marmara 57

12.8.6 The occurrence of an alien shrimp (*Metapenaeus affinis*) in the Mediterranean artisanal fishery 58

13 ToR e) NAFO request on reducing the bycatch of cod 58

13.1 General Overview 58

13.2 Terms of Reference 59

13.3 List of Participants 59

13.4 General issues 59

13.5 Conclusions 63

14 Summary of other presentations 64

14.1 Oral presentations 64

14.1.1 Investigation of the Paired-Gear Method in Selectivity Studies 64

14.1.2 Estimation of Distribution Density of Snow Crab, *Chionoecetes opilio* and Net Efficiency of Survey Trawl for Snow Crab Using A Deep-Sea Underwater Video Monitoring System on A Towed Sledge 65

14.1.3 How Three Different Hauling Techniques Influence Retention Proportions Of Fish In The Norwegian Mechanized Longline Fisheries 65

14.1.4 Fleet spatial dynamics in Portuguese coastal trawlers 66

14.2 Poster presentations 67

14.2.1 Relevance of dual selection in grid based selectivity studies 67

14.2.2 Can codend selectivity of *Nephrops* be explained by morphology? 68

14.2.3 New approaches to selectivity studies in the Barents Sea 68

14.2.4 Modelling escapement during the fishing process as a dual sequence – Introducing SELNET 69

14.2.5 Development of a long range pinger detector for acoustic deterrents used in the set-net fishery 69

15 National Reports 70

15.1 Belgium 70
15.2 Canada 72
15.3 Faroe Islands....................75
15.4 France 76
15.5 Germany 80
15.6 Iceland 84
15.7 Ireland86
15.8 Netherlands 89
15.9 Norway 94
15.10 Portugal....................99
15.11 Scotland....................100
15.12 Spain 103
15.13 United States....................106

16 Report from FAO 119

17 New Business 121

17.1 Date and Venue for 2010 WGFTFB Meeting....................121
17.2 Proposals for 2010/2011 ASC – Theme Sessions....................121
17.2.1 Elasmobranch Fisheries: Developments in stock assessment, technical mitigation and management measures 121
17.2.2 Alternative Fishing Gears 122
17.3 ICES and other symposia....................122
17.4 Any Other Business....................123
17.4.1 Database of global bycatch reduction techniques 123
17.4.2 Eulogy to Professor Fridman 123

Annex 1: List of participants....................124

Annex 2: Agenda....................129

Annex 3:Recommendations....................131

Annex 4: WGFTFB terms of reference for the next meeting....................133

Annex 5:Draft resolution for Workshops 136

Annex 6: WGECO Joint ToR 138

Annex 7: WGFTFB information for other ICES expert groups – questionnaire sent to WGFTFB members 155

Annex 8: Response to NAFO on reducing the bycatch of cod 197

Annex 9: Eulogy to Professor ALEXANDER L. FRIDMAN, ScD (1926–2007) 246

Executive summary

The ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB) met in Ancona, Italy from 18 to 22 May 2009 to address five Terms of Reference. The main outcomes related to the ToRs are detailed below.

Key Findings

Advice to Assessment Working Groups (Section 9)

- As with last year the overall picture from the questionnaires is negative for 2009. 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 stabilised to some degree although in many countries, fuel is still a driving factor in their operational decision making. This is compared to 2008 when vessels tied up because of high fuel prices
- 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 Skaggerak/Kattegat as well as technical measures introduced into ICES Area VIa (West of Scotland) have created difficulties for fleets in a number of countries. There have been 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 has also been a move by a number of vessels 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 sophisticated deck machinery to increase overall fishing time.
- Decommissioning is also still a feature in EU countries with schemes still in operation in Ireland, France, Belgium, Netherlands, Portugal and the Basque region of Spain. While there is evidence these schemes are removing considerable amounts of effort, 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.
- The effects of technological creep are still evident in many fisheries as observed in 2006, 2007 and 2008 but there is continuing indications of negative rather than positive creep due mainly to high fuel prices and also low fish prices more recently.
- As in previous years there have been a number of developments in gear design to reduce drag including the use of dyneema netting and dyneema rope for the construction of headlines to the increasing use of dynex warps to replace conventional wire warp in both pelagic and demersal fisheries.
- 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. In the latter case the influence of public perception of fish being caught sustainably has become increasing important in a number of fisheries notably the Dutch beam trawl fishery as reported in 2008.

- The main ecosystem effect noted has been discarding in a variety of fisheries. Discarding of cod in the North Sea 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 fishermen strive to stay within regulations. There is also evidence that the EU's ban on high grading introduced in 2009 is not being adhered too. There are similar reports of slipping in pelagic fisheries again mainly motivated by quota restrictions and higher market prices for larger fish. Work in Norway is ongoing at assessing the impact of slipping.
- 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 2008 and these are being used on a voluntary basis in many cases. There are also several examples of research into developing low impact trawls through modifications of groundgears. There is also a report from Iceland of an investigation into quantification of the impact of seine gear on the seabed indicating that even perceived low impact gears are now coming under the microscope.
- There are fewer reports in 2009 of increased catches of protected species including cetaceans, sea turtles and sea birds except in the Mediterranean where there still seem to be serious problems. Testing of acoustic deterrent devices is continuing in a number of fisheries and there has also been an interesting joint Danish/German initiative that has seen the successful development of a "pinger" monitoring system. This system has been adopted by the German and Danish fisheries inspectorate and seems efficient.
- Several new fisheries have been reported in 2009. Most of these fisheries are for pelagic species and are potentially at a large scale. There is also continued testing of pots as a means for targeting fish although the indications are that these fisheries are still not economically viable in most cases.

Assessment of Seine Net Fisheries (Section 10)

- From an initial assessment carried out WGFTFB has 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.
- WGFTFB 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.
- There are a number of technological developments in seine net fisheries. Some elements of technological creep were identified as being 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 use of heavier seine rope and heavier groundgears in some seine net fisheries was also identified but could no firm conclusions could be made as whether these significantly increased impact. The development of better deck machinery and gear monitoring equipment was felt to increase fishing efficiency but also to improve safety on board seine vessels and so have positive and potentially negative effects.

Discard policy and framework (Section 11)

- During early 2009 it became apparent that the EU had decided to abandon this proposed approach for the two fisheries indicated although formal notification of this was not received until April 2009. It was therefore decided that there was little point in proceeding to address this ToR at the WGFTFB meeting as there was no alternative approach being proposed by the EU.
- However, it emerged that the issue of discarding had been raised at the sixty-third session of the United Nations General Assembly and also at the twenty-eighth session of the Committee on Fisheries of the Food and Agriculture Organization of the United Nations (COFI) during2009.
- WGFTFB concluded from this discussion that the issue of discarding and bycatch was of critical importance to all WGFTFB members and must remain high on the agenda in developing future work plans for the EG under the ICES Science Plan. Further discussion as to what format this should take, however, is required with input from all participants.

Technical issues relating to the Mediterranean (Section 12)

- Enforcement of installation of square-mesh codends in Mediterranean demersal trawl fisheries can be a suitable technical solution to decrease the capture of immature individuals of roundfish species but not flatfish or deep-bodied species.
- For Red Mullet in the Mediterranean Sea there is preliminary evidence to suggest that the magnitude of escape mortality could be sufficiently high to counteract the benefits of discard reductions through the proposed introduction of new mesh size regulations in 2010; thus leading fisheries managers to overestimate the conservation benefits of these new technical measures. In areas where the exploited population includes high proportions of juvenile fish (which can be more susceptible to escape mortality – Breen *et al*., 2007; Suuronen, 2005), the proposed increases in gear selectivity could lead to substantial increases in total fishing mortality, despite apparent decreases in landed and discarded catch, because of disproportionately large increases in the associated escape mortality. This is particularly likely if fishing effort is allowed to increase in these areas to accommodate for the loss of catch due to the increased size selectivity of the trawl codends.
- WGFTFB identified and highlighted certain parts of Regulation 1967/2006 that could lead to ambiguous interpretations. In Article 9, the statement "at the duly justified request of the ship-owner" is unclear. In Annex II the lack of clear indication regarding the groundrope characteristics (weight, rigging, rockhopper, materials etc.) could lead to uncontrolled and unregulated impact on the sea bottom. Furthermore the impact of multi-rig trawl

nets in the Mediterranean is poorly investigated. The maximum number of nets in multi-rig trawl (i.e. twin trawl, rapido trawl) is not defined in the Regulation and there are indications that several fishermen in Italy have shifted their activity from traditional bottom trawl towards twin trawls. Technical specifications, which limit the maximum dimension of the trawls in Mediterranean, are not yet defined because of insufficient information.

NAFO request on reducing the bycatch of cod (Section 13)

- Behavioral reviews have revealed that differences between cod and other species do exist, either in terms of natural separation or in its reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations.
- WGFTFB cautions that in the absence of specific details such as gear descriptions, vessel types and management objectives, no single gear modification can be recommended to NAFO at this time. WGFTFB, however, has identified some gear modifications which demonstrate that the separation of cod from other species, including flatfish, is possible. This can be achieved by modifying the front section of the trawl, installing a sorting device such as a rigid grid or separator panel, by using large mesh escape panels positioned above the codend or by modifying the codend itself. These do need, though, to be tailored to the specific requirements of a given fishery and limitations with all of these gears have also been identified and documented. Other modifications such as the "Eliminator" and Raised footrope trawls have been proven to eliminate cod catches almost entirely but are only really suitable for targeted haddock fisheries.
- Studies examining separation techniques for non-trawl gears were also identified and briefly reviewed. These include modifications to Scottish seines, gillnets, longlines and pots. Testing of gear modifications to Scottish seine nets is an extension of similar modifications made to trawls. The limited data available is inconclusive but it seems technically feasible to target flatfish with this gear with reduced cod catches.
- There has been extensive work with gillnets in recent years and through simple modifications significant reduction in cod catches can be achieved when targeting flatfish species. Gillnets are accepted as selective gears and further research on a commercial basis to establish whether these modifications can yield catches at economically viable levels of other species should be encouraged.
- Using bait to sort catches in longline fisheries seems technically feasible but has only really been used to reduce cod catches in targeted haddock longline fisheries. More research is needed to establish whether this can be extended to other fisheries where cod is considered an unwanted bycatch due to stock pressures.
- Experiments with fish pots are widespread in many areas and fisheries. Most of this work has concentrated on developing selective fisheries for cod. There are several reports of attempts to develop flatfish pot fisheries but catch rates observed have been at low levels and pot fisheries for fish remain in a developmental phase.

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 used in bycatch and discard reduction; as well as benign environmentally fishing gears and methods used to reduce impact on bottom habitats and other non-target ecosystem components, including behavioral, statistical and capture topics.

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: Ancona, Italy
Date: 18–22 May 2009

2.1 Terms of Reference

The ICES/FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] (Chair: Dominic Rihan, Ireland) will meet from 18 to 22 May 2009 in Ancona, Italy.

a) Incorporation of Fishing Technology Issues/Expertise into Management Advice. Based on the questionnaire exercise carried out in 2005/2006, 2006/2007 and 2007/2008

b) A WGFTFB topic group of experts will be formed on seine net fisheries with 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 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.

c) A WGFTFB topic group of experts will be formed with the following ToRs:

i) To review and appraise the current selectivity characteristics of the gears used in the Area VII *Nephrops* trawl fisheries and Beam trawl fisheries for flatfish in ICES areas IV and VIId; and

ii) To propose potential gear modifications that could contribute to the future technical conservation measures needed to achieve the targets proposed by the European Commission, while also taking into account fish survival from such gear modifications.

d) A WGFTFB topic group will be formed with the following ToRs:

i) Review progress with better developing scientific collaboration of WGFTFB with GFCM on fishing technology issues in the Mediterranean; and specifically

ii) Review new research with 40mm square-mesh codends introduced recently into EU legislation for the Mediterranean;

iii) Assess the efficacy of this measure in terms of improved selectivity and fish survival;

iv) Identify whether from a technical perspective that the regulation needs to be amended i.e. twine material, meshes in the circumference.

e) A WGFTFB topic group will be formed "to advise NAFO SC on appropriate gear modification, or other technical measures relating to fishing gears, that would ensure that the bycatch of cod is kept at the lowest possible level".

2.2 Participants

A full list of participants is given in Annex 1.

2.3 Explanatory note on meeting and report structure

The approach adopted in 2004 of addressing specific ToRs was adopted for the 2009 meeting. The agenda is given in Annex 2. Individual conveners were appointed during 2008 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, summarising 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, finalise their reports and findings, and produce a presentation to the WG and prepare a final report for inclusion in the WGFTFB 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.

The chair outlined that were possible this format will be adopted for the foreseeable future although with the adoption of the new ICES Science Plan, a full debate on the future structure and composition of WGFTFB is planned during 2009/2010.

3 WGFTFB advice and requests during 2008/2009

3.1 Overview

During 2008/2009, WGFTFB dealt with the following requests for advice:

- NAFO request on reducing cod bycatch (See Section 13)
- EU request on available scientific information on the impacts of destructive fishing practices, unsustainable fishing, and IUU fishing on marine biodiversity and habitats (pending).
- EU request on Baltic cod selectivity (to be dealt with by an *ad hoc* group in August/September 2009) as follows:

  "For metiers using towed gears in the Baltic Cod fisheries, what are the current L0, L100 and L50 (length of first catch; length corresponding to the maximum level of vulnerability; length corresponding to a vulnerability representing 50 % of the maximum one) related to selectivity ogives already evaluated for towed gears used by those metiers in such fisheries.

  By considering a similar exploitation pattern to this currently observed, what would be the L50 that would maximise yield per recruit?

  By taking into account similar selectivity ogives to those already evaluated for towed gears In the Baltic cod fisheries, what should the L50 be to eliminate (or to reduce to very low levels - wouldn't we have to specify such levels ?) catches of cod below the Minimum Landing Size (38cm) ?

  For each of the above two L50s, describe:

  What would be the expected evolution to be observed in yields in the short and in the long terms?

  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?

  The same questions shall apply for metiers using static gears in the Baltic Cod fisheries (e.g. gill nets with their correspondent parameters)."

No other formal requests were received during 2009. The chair of WGFTFB did attend the WGCHAIRS meeting in February 2009 and contributed by correspondence to the SGBYC meeting held in January 2009.

4 Report from theStudy Group on the Development of Fish Pots for Commercial Fisheries and Survey Purposes (SGPOT)

The Study Group on the Development of Fish Pots for Commercial Fisheries and Survey Purposes (SGPOT) held its third and final meeting in Ancona, Italy on 16–17 May 2009 prior to the WGFTFB meeting. The meeting was attended by 14 participants representing 10 countries. The terms of reference for this meeting involved mainly the final planning of a Cooperative Research Report (CRR) from the group's three-year work.

The CRR, which will be edited by Bjarti Thomsen and Michael Pol, will include the following chapters (chapter authors in brackets):

i) Introduction (editors):

ii) Terminology, including definitions and drawings of various types of fish pots, entrances etc. (Philip Walsh).

iii) Commercial and scientific worldwide use of fish pots, including examples of (low) economic viability that stress the need for further development to increase efficiency, and pros and cons as a research tool (Bjarti Thomsen and David Stokes).

iv) Historic and current research, using a model describing attraction, capture and retention (Mike Pol, Peter Munro, Svein Løkkeborg, Steve Kaimmer, Bjarti Thomsen).

v) Dark side of fish pots, describing unaccounted mortality including ghost fishing and gear conflict etc. (Mike Breen).

vi) Future research needs and recommendations, using same model as chapter 4 (Mike Pol, Peter Munro, Svein Løkkeborg, Steve Kaimmer and Bjarti Thomsen).

vii) Bibliography, an extensive list of papers on fish pots (Bjarti Thomsen)

Chapters 2–5 have been discussed in the two previous meetings and the bulk of text for these chapters already exists. Chapter 6 will be main part of the CRR and preparations for this chapter were progressed significantly at this year meeting.

The group agreed on a first draft deadline of 19 October 2009 and the final draft deadline of 18 February 2010. The editors expect the final draft to be submitted to ICES one month later for publication.

SGPOT has prepared an ICES resolution for an internal publication of the CRR.

In addition to the CRR, several countries have ongoing research on fish pots and a session was allocated to allow participants to present on current and new fish pot research. These presentations were:

- Sonia Mehault, France: Testing of different fish pot design in French waters.
- Sara Königson, Sweden: Swedish development of fish pots, including making them 'seal safe'.
- James Mair and Mike Breen, Scotland: Fish pots used as survey tool.Stephen Kaimmer, US: Observations of halibut behaviour around fish pots.
- Francesco De Carlo, Italy: Comparing one and two entrance Norwegian fish pots.

- Antonello Sala, Italy: Further statistical analysis on the above item.
- Philip Walsh, Canada: Atlantic cod potting, handling and marketing.
- Mike Pol, US: Seasonality and comparison of Canadian and Norwegian fish pots for Atlantic cod.
- Haraldur Einarsson, Iceland: Attraction of Atlantic cod to fish pots using trained fish.
- Bjarti Thomsen, Faroes: Use of vibrating devices to attract fish.

The group also suggested a theme session on alternative gears as a follow up to the Study Group to be proposed for the ICES Annual Science Conference in 2010 (see Section 17.2)

5 Report from the Study Group on combining gear parameters into effort and capacity metrics (SGEM)

The Study Group on combining gear parameters into effort and capacity metrics (SGEM) met at ICES HQ, Copenhagen, Denmark from 11 to 13 August 2008. Attendance at the meeting was very poor, with only the two Co-Chairs present. This restricted the scope of possible work.

SGEM (Co-Chairs: Dave Reid, Ireland and Norman Graham, Ireland) will meet in Galway, Ireland from 11–15 August 2009 to:

a) Review work carried out on measuring relative/effective effort by geartype and where possible determine the relationship between vessel construction (tonnage, power, length etc.) and the size or quantity of fishing gear deployed;

- Scottish North Sea (IVa) demersal otter trawling for mixed whitefish. The review will focus on the following fisheries:
- Irish Celtic Sea (VIIj,g) demersal otter trawling for mixed whitefish
- Scottish North Sea (IVa) demersal otter trawling for mixed *Nephrops* and whitefish
- Irish Celtic Sea (VIIj,g) demersal otter trawling for mixed *Nephrops* and whitefish
- Scottish pelagic trawling for mackerel
- Irish pelagic trawling for mackerel
- French gillnet fishery for hake

b) Investigate the linkage between wingend spread, the use of single and multiple rigs on the efficiency of trawls used for targeting Pandalus shrimp.

In respect of a) above the conveners requested WGFTFB members to provide data from experimental trials where both vessel and gear metrics have been recorded. This data will be compiled during the meeting to quantify the relationships between vessel and gear parameters. In particular the following information is required:

- Vessel – power, length, type
- Gear – type (e.g. single/twin), gear size (circumference), groundgear, door/wing spread, Headline height, gear quantity (static gears).

6 Update on electric beam trawl work

In November 2005, ICES received a request from the European Commission Directorate General for Fisheries and Maritime Affairs regarding the then current regulation that banned the use of fishing techniques that use electrical stimulus for fish capture and specifically dealing with a request from Netherlands regarding the use of an electric beam trawl system. The Chair of WGFTB was asked to formulate a multi-disciplinary *ad hoc* Expert Group to consider the request. This Expert Group reported back to ACFM in May 2006.

This advice was adopted by ACFM and forwarded to the EU. The EU's Scientific, Technical and Economic Committee for Fisheries (STECF) then assessed it further in November 2006 with further input from WGFTFB. STECF largely concurred with the WGFTFB advice and concluded:

> "Although the development of this technology should not be halted, there are a number of issues that need to be resolved before any derogation can be granted."

As it transpired, however, the EU ultimately rejected this assessment and introduced a derogation to allow electric beam trawling on a restrictive basis under Annex III (4) of Council Regulation (EC) No. 41/2006. The Dutch fishing industry is currently fitting out a total of five vessels with pulse trawls and winches under derogation from the present ban on using electricity in fishing of the EU (EC Reg. No 850/98 of 30 March 1988). This involves substantial investments by the industry, which will partly be subsidized by the Dutch government. Further implementation in the Dutch fleet depends on lifting the EU ban, emphasizing the importance of a positive verdict from the scientific community. The first vessel in the row MFV TX68 is currently starting to work with the new system. In addition the Dutch government are seeking to have the ban on electric fishing removed from EU legislation. This requires, however, that the concerns raised by ICES and ACFM are addressed. Since 2006 a number of experiments have been carried out by IMARES in the Netherlands and these were outlined to WGFTFB by Bob van Marlen.

The first set of experiments looked at the measurement of field strength and pulse characteristics used in the pulse trawl system. Both experiments in a basin at the company who designed the system and on board a commercial vessel were carried out. However, the data has not been presented on confidentiality grounds although it was stressed that the electric field does not extend far outside the trawl so the impact is minimal outside the immediate tow path of the trawl.

Experiments assessing the effect of electrical stimuli on cat sharks (*Scilliorin caniucula)* were also completed by IMARES. These were carried out as tank tests with a pulse stimulator with two electrodes. Video recordings of behaviour under stimulus and feeding behaviour subsequently were made and assessed. The results showed that the electric stimulus did not induce higher mortality in sharks although there were difficulties with the methodology and husbandry of the study animals. Further experiments were conducted on cod (*Gadus morhua* L.) in a field station at Austevoll in Norway, also with the animals fixed in a cage at three different positions from the electrodes of the pulse stimulator mentioned above. The distances were: 1) a "near field" range with the fish exposed at 10 cm from the conductor element; 2) an "above field" range with the fish exposed at 20–30 cm above the centre of the conductor elements; 3) a "far" field" range with the fish exposed at 40 cm side ways of a conductor element. The tests showed that spinal injuries and even mortality can occur when the animals are close to the electrodes. This is not the case when they remain at distance at the "above field" range. Neither damage nor mortality was found for a control group exposed to a similar treatment, except the electrical stimuli. Additional experiments on invertebrates will be carried out this year.

A final set of experiments were carried out on cod. This involved x-ray tests carried out by IMARES on gutted cod obtained from the vessel with the pulse system installed. These tests showed 2 out of 25 fish had clear spinal damage and 6 out of 25 had deformed spines.

Further work is also being undertaken under the EU DEGREE project to calculate the effects of introducing electric fishing on benthos using the sediment effect model developed in this project.

On the basis of all of this work the Dutch Ministry have indicated that they will be making a formal request to ICES to assess whether the results from these experiments satisfy the reservations made in 2006. It is suggested this would be done through an ICES Workshop. The ToRs for this workshop are outlined in Annex 5.

7 Update on Gear Classification Topic

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 2008/2009. 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 (Table 1) to coordinate the process of finalising 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 as well as those in Table 1.

- 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

FAO also indicated that there were other issues on which CWP might ask for technical advice from ICES, relating to the definition of fisheries, fishing effort variables and classification of fishing vessels.

Table 1. List of participants in Ancona meeting on 19 May 2009

R S T Ferro	FAO consultant (Chair)
S Tsuji	FAO, CWP Secretary
F Chopin	FAO FIIT
B Chokesanguan	WGFTFB/SEAFDEC
S Eayrs	WGFTFB
W Thiele	WGFTFB/FAO

8 WGECO request on gear efficacy framework

A joint ToR was addressed by members of WGECO and WGFTFB at the 2009 WGECO meeting held in Copenhagen in April 2009. This ToR was as follows:

ToR b) "Using two existing fishing gear types, describe the significant adverse impacts of those gears for the ICES area, using the methodology developed by WGECO in 2008. Highlight issues that are specific to geographic areas and those that are generic to the gear. Based on this process recommend any modifications to the methodology required to make it operational".

A summary of the report produced at WGECO is given below. The full text is included in Annex 6.

Background

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 which identified the significant adverse impacts (FAO 2008) of particular fishing gears that should be considered in experiment planning for developing mitigation measures. Throughout this report "significant adverse impacts" is abbreviated as SAI, and "No significant adverse impacts" is abbreviated as NSAI.

It was, however, identified that in order to develop the methodology further and make it operational it required trialling for existing gears. It was also identified that the terminology used for the criteria that defined significant adverse impact would need further consideration as for some aspects of the ecosystem this terminology is poorly defined (see tor a in WGECO report of 2009 in preparation). In addition, the grouping of ecosystem components within assessment categories was revisited.

The objective of this ToR was to work through an assessment of the significant adverse impacts of two specific fishing gears and using the experience 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. These two gears were selected as they represented one gear (beam trawls) that is well studied with an accepted high impact on habitats and benthos, and a second gear (gillnets) that has documented marine mammal and seabird bycatch impacts but is recognised as being environmentally benign in most other respects.

Vulnerability of species to particular fisheries is dependent partly on the likelihood of them suffering any mortality due to the fishery, and also on their sensitivity to the fishery.

- Mortality should be interpreted as any mortality resulting from the fishery, including both mortality sustained in the catch and in the path of the gear (e.g. in the towpath of the gear on the seafloor, or after passing through the gear). This is as defined in 2008.
- Sensitivity is itself a function of the resistance of the species to the fishery (its' gear and behaviour), and the resilience of the species to raised levels of mortality (ability to recover) (Bax and Williams, 2001; Zacharias and Gregr, 2005).

There is much literature describing life history and ecological characteristics that are associated with high vulnerability to fisheries and these sources should be consulted by experts in this field when applying this methodology.

The assessment was carried out on four ecosystem component categories:

- 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.

Species "previously identified" refers to species listed in accepted fora such as IUCN or the OSPAR list. If species included in these lists are impacted then the impact of the fishing gear should be classified as SAI. We have also taken the approach that when a species or habitat is listed as at risk of extirpation or complete loss, ANY mortality or damage would represent SAI. It should be noted that these lists should not be over relied on as they are essentially "works in progress" and merely because a species or group of species does not appear on these lists does not necessarily mean they are not Significantly Adversely Impacted.

Testing of Methodology developed by WGECO 2008

The methodology developed by WGECO (ICES, 2008b) for the various ecosystem components was modified at WGECO in 2009. This was then used in a test assessment for two case study fisheries: Flatfish beam trawls in the North Sea and bottom set gillnets in the Baltic. Applying the methodology *for real* will require a group of experts covering all ecosystem components for which the generic impact assessment identifies there is a high risk of impact, and who also have local knowledge for the area being assessed. Ideally, a group of three or more experts per component should be available, and an audit trail should be completed as the assessment is undertaken.

Any expert judgement based approach should be accompanied by an analysis of uncertainty to account for the level of knowledge available to support the assessments made for each ecosystem component. Uncertainty is usually recorded as confidence and here we have followed the categorisation of confidence described by Robinson *et al.* (2009) where:

- High confidence should be given when data are available, particularly in the form of GIS outputs for the period being assessed, and/or a group of experts (>3) agree that they have high confidence in the assessment.
- Low confidence should be given where detailed information is not available for the period being assessed, or is not available at all, and/or there is no agreement, or the number of experts involved is <4.

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 ground gear. 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 gill net 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.

The assessment outcomes by gear type and ecosystem component group are summarized in Table 2.

Table 2. Assessment outcomes by gear type and ecosystem component group

Ecosystem Component Group	Beam Trawls in the North Sea	Bottom Set Gillnets in the Baltic Sea
Commercial fish species	SAI for sole, cod and whiting NSAI for plaice No evaluation for unassessed species	SAI for cod and flounder No evaluation for turbot
Listed species including fish, cephalopods and benthos	No evaluation due to no agreed list	No evaluation due to no agreed list
Marine mammals, marine reptiles and seabirds	NSAI	SAI for harbour porpoise and seabirds NSAI for seals
Pelagic and benthic habitats and assemblages	SAI for impact on productivity, structure and function of habitats except pelagic SAI for impact on benthic and fish assemblages	NSAI for any impacts

Emergent issues

In carrying out the assessment, a number of difficulties arose that may have resonance for other assessments both for gear, and for other pressures.

- What is the minimum level of proportional impact that would constitute an important pressure? For example, if a particular gear, caught less than 5% of a fish stock that was below B_{pa}, would that gear pressure is assessed as a "cause" of that SAI evaluation? Equally, while beam trawling is acknowledged as having a major impact on the North Sea habitats, this will compounded with otter trawl impacts that are also acknowledged as major (Kaiser *et al.* 2006, Løkkeberg 2003).
- Standard reference points for assessed fish species are B_{pa} and B_{lim}. We have indicated here that when a stock is over B_{pa} in the current year, it can be considered as NSAI, even when it has been below B_{pa} over a number of previous years. Is there a need for a time scale factor, e.g. "has been below B_{pa} for 4 out of the last 5 years"?
- Again, we assessed stocks below B_{pa} as SAI. However while B_{pa} requires reduced fishing to allow recovery, SAI requires a complete halt to the responsible activity. The two concepts are not mutually compatible in terms of response.
- What are the appropriate "natural" reference conditions? OSPAR defines these as "pre-industrial". But for instance, beam trawling in the southern North Sea was responsible for permanently modifying the physical habitat many years ago; removal of boulders and oyster beds. This is likely to be irreversible. Is it sensible to permanently assign an SAI category on this basis? Or should we consider more recent impacts and take the reference as the modified habitat? Similar questions arise for seabirds and other components.
- What geographic extent constitutes an important impact? If one small area is very seriously impacted, but the rest is largely pristine, how does one assign SAI/NSAI? The distributional ranges for vulnerable or endangered species are particularly important in this context; e.g. is the species endangered across its range or locally.

- In many species cases, especially fish, a whole stock for a species may be below B_{pa}, and therefore in an SAI status. At the same time, it may be possible that individual pressures e.g. from different gears do not make an important contribution to that status assessment. Equally, one stock of a species may be SAI, while another may not. There is probably a need for a nested approach to such species evaluations.

Discussion

In general the members of WGFTFB welcomed this initiative but caution was urged in the use of Significant Adverse Impact (SAI) as defined by the FAO for high seas bottom trawl fisheries. 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. 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. The chair stressed this was a draft framework that needed further work and also clarified that there had been considerable discussion at WGECO about this very issue. Further refinement is definitely needed and the methodology developed needs to be tested with some actual gear modifications to see whether it will work in practice. A joint ToR will be drawn up with WGECO on this basis and agreed at the ICES ASC in 2009.

9 ToR a) Advice to assessment WGs

9.1 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 fishermen 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 for 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. In 2009 this information has now been included as an Annex to the stock assessment reports.

9.2 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.

9.3 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 2009 (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 recognised 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 WGFTFB 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
IMR, Sweden	FRS, UK-Scotland
IPIMAR, Portugal	IFREMER, France
BIM, Ireland	IMR, Iceland
AZTI, Spain	FFL, Faroe Islands
ILVO, Belgium	CNR-ISMAR – Italy
VTI, Germany	

The conveners worked by correspondence and the information provided were collated by the chair during the WGFTFB meeting. The full information for individual ICES Expert Groups is given in Annex 7 but some of the general issues raised are summarised as follows:

Fleet Dynamics

As with last year the overall picture from the questionnaires is negative for 2009. 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 stabilised to some degree although in many countries, fuel is still a driving factor in their operational decision making. This is compared to 2008 when vessels tied up because of high fuel prices.

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 Skaggerak/Kattegat as well as technical measures introduced into ICES Area VIa (West of Scotland) have created difficulties for fleets in a number of countries. There have been 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 has also been a move by a number of vessels 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.

Decommissioning is also still a feature in EU countries with schemes still in operation in Ireland, France, Belgium, Netherlands, Portugal and the Basque region of Spain. While there is evidence these schemes are removing considerable amounts of effort, there are indications in several countries that some of this effort is being re-introduced 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.

Specific changes to highlight the trends observed include the following:

- The new days at sea regulations have caused serious problems for many vessels in the Irish fleet given under the first pilot period of February to the end of April 2009 many vessels received very small effort allocations. This has resulted in wide spread effort shifts from Area VIa and VIIa into Area VIIb-k. In particular there has been increased effort in the *Nephrops* fisheries in Area VIIg and VIIb. In VIIg at least 5 vessels of around 24m/550hp have been forced to move from VIIa to VIIg and VIIb due to the fact this were replacement vessels for owners who had decommissioned. These vessels had no track record and so got no entitlements in VIIa.
- The new technical measures in a substantial part of Area VIa, which require the use of increased codend mesh sizes and square mesh panels have resulted in a significant drop in effort in Area VIa since the beginning of 2009. Since January it is estimated that only two of the larger whitefish vessels in the NW have fished inside the restricted area and have reported catch reductions of between 30–40% of all species with the new mesh sizes. These regulations have also caused effort to be shifted to the Rockall fishery as mentioned as 3–4 of the larger whitefish vessels have been forced to participate in this fishery from Feb/March onwards rather than April as in previous years. It seems likely that effort in VIa will be at a very low level during 2009 as it is uneconomic for vessels to fish with the larger mesh size codends.
- In 2008 due to the days and fuel used steaming to Rockall many Scottish vessels which would have targeted these grounds instead targeted west coast or North Sea grounds. A few vessels made single trips to Rockall but the returns were poor and therefore proved a disincentive to other vessels making the long journey. From 1st February 2009, however, many of these Scottish vessels have now reverted back to the Rockall grounds which has now become attractive due to the steaming and fishing time not counting against days at sea days at and because fuel costs have reduced. These vessels are targeting haddock, anglerfish and megrim; however, this could lead to a quick uptake of Rockall quotas.
- Up to 3–4 Scottish vessels have also moved from the North Sea and west of Scotland to Area VIIb-k in 2008 and 2009. These vessels are all large vessels 24m+ and are targeting *Nephrops* at the Porcupine Bank and Labadie Banks.

This is thought motivated by the fact that there aere no days at sea limitations in VIIb-k.

- In the first quarter of 2008, the number of Swedish vessels fishing (and effort deployed) in the Kattegatt decreased due to an increased effort cost (2.5 days at sea per effort day deployed). This effort was mainly been reallocated to the Skagerrak or the Baltic Sea. Vessels without the possibility to change area mainly targeted *Nephrops* using grid-equipped trawls (i.e. a gear with effort limitation).
- The effort quota system (days at sea allocation) in the Faroes has resulted in decreasing number of boats in the fleet of small trawlers targeting flatfish inside 12 nautical mile zone. However, the remaining boats have been able to fish with essentially unlimited days as the allocation to this segment can sustained this level of effort with the number of vessels remaining
- There are 3 French vessels and approximately 10 Dutch vessels (with a further 3 under construction) that have switched to Scottish seining. These vessels are around 24m+/650hp-1200hp. The French vessels have reportedly been targeting whiting in particular but also cod and non-quota species in Area VIIb-k (mainly VIIg) for the 1st and 2nd quarter of 2009. These vessels, along with the Dutch vessels are also working in VIId and IVb for non-quota species such as red mullet, squid and gurnard. They are fishing with ~50mm diameter seine rope and are hauling the last two coils of the "ring" at 5 knots compared to 1–1.5 knots by Scottish and Irish seiners. These vessels can complete up to 8–10 rings in a day compared to 5 or 6 by Scottish and Irish vessels. This represents a considerable increase in effort in this fishery.
- Since 2008, 24 boats out of 320 boats were decommissioned from the Dutch beam trawl fleet (7.5% reduction). A number of these vessels have been subsequently using passive licences. There is a tendency to opt for smaller multi-purpose vessels replacing the conventional beam trawler.
- The Belgian fishing fleet numbered 102 fishing vessels in the beginning of 2008 and has now been reduced in 2009 to 98 active vessels due to 4 vessels going bankrupt.
- There has been decommissioning of Swedish Baltic/Kattegat cod trawlers during 2008/2009 both old and newer vessels have been removed from the fleet - 10% in numbers, 15% in capacity. This has been driven by low quotas for cod, new days at sea regulations and low prices.

Technology Creep

The effects of technological creep are still evident in many fisheries as observed in 2006, 2007 and 2008 but there is continuing indications of negative rather than positive creep due mainly to high fuel prices and also low fish prices more recently.

As in previous years there have been a number of developments in gear design to reduce drag including the use of dyneema netting and dyneema rope for the construction of headlines to the increasing use of dynex warps to replace conventional wire warp in both pelagic and demersal fisheries.

As mentioned previously there has also been a move away from trawling to seining and also development of new deck machinery and heavier seine ropes to improve the effective fishing time and also the catching efficiency of this gear. Similarly in a number of countries, notably Norway there has been attempts to use pelagic gears for targeting demersal species such as saithe and cod.

In the Basque region of Spain, as pelagic species such as mackerel become more important, there has been increasing use of on board processing equipment such as vacuum pumps and also triplex haulers.

Specific examples of technological creep are given below:

- A number of vessels have started to use trawls with Dyneema headlines of 10–12mm. This has reduced the overall drag of their gear and is motivated by high fuel costs in 2008. One seine net vessel reports a reduction in fuel consumption of around 400 litres per day fishing.
- There has been an increase in the use of dynex warps from steel wires in the pelagic fisheries by Icelandic and Irish vessels. The use of dynex reduces drag considerably compared to traditional warps and vessels can tow faster.
- 3 Scottish seiners are now fitted with seine power reels that allow them to haul without using a seine winch. This considerably increases the efficiency of the operation and allows an extra haul per day. These vessels are currently working in the North Sea but this could spread to the west of Scotland at a later date. Most of the French seiners working in VIIb-k are also using this system.
- In 2009 more and more Belgium beam trawlers are using roller gear instead of the standard trawl shoes to reduce fuel consumption. About 3 vessels are also investigating the Dutch sumwing bam trawl to reduce fuel consumption as well. It is expected that this initiative will lead to gear modifications used in beam trawls, depending on legislation changes.
- In the Basque fleet there has been a recent introduction of vacuum pumps to handle fish in the purse seine fishery for mackerel in VIIIc. This mainly to optimize fish handling and reduce processing time at sea. One of the main aims of the technological creep has been the improvement of safety and comfort of the crew. No estimation on catchability has been carried out so far although the main proven effect is the reduction in the time spent to handle the catch and subsequently the haul duration. Triplex haulers have also been fully implemented in the purse seine and pole and line fleet segment in VIIIc. Net clearers have been implemented in an important number in the coastal gillnetters (artisanal fleet) in VIIIc.
- In the last few years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single to twin-rig trawling (named by the Italian fishermen: *"Americana trawl"*). This change has been introduced to increase the bosom height as well as the horizontal opening of the trawl made. There is a big concern, though from fishermen 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.

Technical Conservation Measures

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. In the latter case the influence of public perception of fish being caught sustainably has become increasing importance in a number of fisheries notably the Dutch beam trawl fishery as reported in 2008.

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

- A new closed area regime was introduced in the Kattegat in 2009 to protect Kattegat cod. Among other measures four different zones for gear usage were introduced whereby both the Swedish grid and a Danish SELTRA-trawl (>300 mm SMP in the codend top panel) are mandatory in a large part of the area. The driver for this is access to otherwise closed areas (the Kattegatt closure, Swedish coastal waters). Exclusion from the kW-day system for Swedish vessels using the *Nephrops* grid and square mesh codend. This closure is expected to shift effort by Swedish and Danish vessels into other areas, e.g. Baltic.
- The use of Bycatch Reduction Panels (BRP) in the lower sheet of beam trawls is studied on FRV "Tridens", with voluntary uptake by several Dutch beam trawlers. Some twin-trawlers are also using a similar BRP in the top sheet. Indications are that plaice discards can be dropped by 20%.
- The Producers' Organisation in Belgium has set up a working group of ship owners to test gear modifications to beam trawls. The testing is partial funded nationally and partially voluntary testing. Gear modifications tested include a square mesh panel in the upper-aft of the trawl and bigger diamond meshes in the top panel. Both modifications have been tested in the Central North Sea in 2009 to reduce the by-catch of unwanted roundfish, particularly whiting and cod. Beam trawler (1200hp) fishing in the Irish Sea is using a combination of T90-codend, benthos release panel, big meshes in the top panel and roller gear. These modifications have been tested in 2006 on a project scale and are now used by the same vessel on voluntary basis.
- From 2009 many Scottish *Nephrops* vessels targeting west coast grounds in VIa have been using 160mm SMP's to demonstrate to the Commission that they are definitely not targeting fish and have moved to a single species fishery. This has been driven in part by concerns for the potential of the Swedish grid being imposed on west of Scotland *Nephrops* fishery if quotas are used up towards the end of 2009.
- French vessels working in the Bay of Biscay VIIIa & VIIIb have been using a combination of increasing mesh size from 70 to 80 mm; using drop out panels on the bottom sheet of the extension of the trawl (Square mesh with 60 mm bar size) or using flexible *Nephrops* grid with 13 mm bar spacing. Trials have shown a reduction of *Nephrops* discards (below 9 cm total length) of 35% for the 13 mm grid, 30% for 80 mm, 25% for square mesh drop out panel. The use of these devices is voluntary.
- In Iceland more than half the shrimp fleet are using extra codend with 135mm mesh to collect fish released from the opening at the top of Nordmore grids with a bar spacing of 22mm used in this fishery. The idea is to retain some of the fish catch in this fishery mainly due to low price for shrimp.

- Experiments in the Norwegian trawl fishery for blue whiting and Norway pout along the Norwegian Trench have been carried out to reduce the by catch of saithe and to some extent haddock. Experiment performed 2008 with both flexible and rigid grid systems with 40 millimetre bar spacing have proved to reduce the by catch substantial ~90% in some cases. From 1 January 2009, the trawlers are allowed to have a maximum of 5 % mixture of saithe (by weight) in the landings of blue whiting and effectively meaning that they have to use a grid device to comply with the rules.
- Efforts have been continuing between the Faroe Islands and Russia to introduce the flexi grid on board Russian pelagic vessels targeting blue whiting. Faroese, Norwegian and Icelandic vessels now all use the flexi grid developed in this fishery but the Russian vessels do not currently as they say fish catch is reduced considerably. Joint trials are being conducted.

Ecosystem Effects

The main ecosystem effect noted has been discarding in a variety of fisheries. Discarding of cod in the North Sea 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 fishermen strive to stay within regulations. There is also evidence that the EU's ban on high grading introduced in 2009 is not being adhered too. There are similar reports of slipping in pelagic fisheries again mainly motivated by quota restrictions and higher market prices for larger fish. Work in Norway is ongoing at assessing the impact of slipping.

Specific examples of discarding reported include:

- High discarding of cod in Area VIIb-k was reported in Q3 and Q4 in 2008 due to exhaustion of quota. This is likely to be repeated in 2009. Discarding has been widespread across all Irish demersal fleets. An example of the scale is reports from the owner of one seine net vessel, who discarded over 30 boxes of marketable cod (1–1½ tonnes) from one 5–6 day trip. The problems in 2008 have been put down to poor quota management which effectively led to unrestricted landings during February-March. Heaviest landings were made by the Irish gillnet fleet of around 6-8 vessels. Heavy landings led to very low prices and cod were sold as low as €1.20–1.40/kg during this period.
- During Q1 of 2009 there have been large quantities of mackerel in Area VIa both inside and outside the French Line. All of this fish is being discarded due to quota restrictions and is reported to be on a wide scale. During trials on an Irish vessel in April catches of up to 4 tonnes per tow were recorded.
- There are problems in the UK with the uptake of the whiting, saithe and cod quotas. The whiting quota was almost 50% taken by April 2009, with the saithe and cod quotas around 40% caught. It is anticipated this will lead to further discarding of these species later in the year. The fishermen claim whiting particularly are very abundant in the North Sea this year).
- There is anecdotal evidence in both Scotland and Belgium that the ban on high grading introduced into the North Sea under the TAC and quota regulations for 2009 is not working. There are reports fishermen are ignoring these regulations and discarding large quantities of small grade cod due to the quota being very limiting.

- There were reports of widespread slipping of mackerel and horse mackerel in Q4 of 2008 and Q1 of 2009 by pelagic vessels from all countries. This was due to a high predominance of small mackerel on the ground with a low market value. It was also driven in Ireland by the management regime that does not allow vessels to land horse mackerel with more than 5% of mackerel bycatch. There is still no assessment of the scale of slipping in these fisheries or their likely impact.
- In May 2008 a first field experiment was conducted by Norway to study the mortality of herring after crowding and slipping. The experiments were carried out onboard commercial purse seine vessels in the open sea. It was shown that the mortality was dependent on the degree of crowding. Further experiments have to be done to provide reliable mortality estimates.

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 2008 and these are being used on a voluntary basis in many cases. There are also several examples of research into developing low impact trawls through modifications of groundgears. This has mainly looked at using a combination of roller bobbins and plates instead of traditional rockhopper groundgear. Results appear a little mixed but there are some indications that this is technically feasible and does reduce impact. There is also a report from Iceland of an investigation into quantification of the impact of seine gear on the seabed indicating that even perceived low impact gears are now coming under the microscope.

Specific examples include the following:

- The beam trawl fleet in both Netherlands and Belgium are feeling the increased pressure of the market not wanting to buy fish caught with beam trawls due to the bad reputation. This incentive is stimulating research on selective nets and ways of diminishing impact. Initiatives have been taken to promote fish products from ecosystem friendly methods, e.g. outriggers. In the UK the Seafish Responsible Fishing Scheme is being used in a similar way but up to 300 UK vessels to promote their catch. These initiatives are likely to continue over the next few years.
- The Dutch beam trawl fleet are voluntarily using longitudinal release holes and benthic release panels made of square mesh in the lower panel of the trawl, which open when nets fill with benthos. Research is being carried out with the industry to optimise a Benthic Release Panel for the Dutch beam trawling segment. This work is continuing in 2009.
- There has not been a major shift in mesh size categories (anecdotic information) although some of the Belgian beam trawler fleet have been fishing with trawl nets of 150mm mesh size instead of 120mm in the belly of the net during the summer of 2007 and 2008. These changes are especially prevalent on fishing grounds with a lot of weed, hydrozoans and bryozoans, namely ICES subarea IVb and VIIg.
- Experiments with a combined plate gear with rolling bobbins have been carried out on Norwegian research and commercial vessels in 2007. The final concept was tested in November 2008 and combines roller bobbins and plate gear. Initial assessment suggests this gear has a lower bottom impact than standard rockhopper groundgears but further testing is required.

- A preliminary investigation was carried out in Iceland to measure the bottom impact of seine gear. The seabed was filmed before and after as well as biological samples taken but no evidence of substantial impact was found. This work is continuing.

There are fewer reports in 2009 of increased catches of protected species including cetaceans, sea turtles and sea birds except in the Mediterranean where there still seems to be serious problems. Testing of acoustic deterrent devices is continuing in a number of fisheries and there has also been an interesting joint Danish/German initiative that has seen the successful development of a "pinger" monitoring system. This system has been adopted by the German and Danish fisheries inspectorate and seems efficient.

- In the last couple of years there are a growing number of sea turtles accidentally being caught by bottom and pelagic trawlers in the Central Northern Adriatic Sea. It is estimated that in this area more than 4000 turtles per year are caught.
- In the Tyrrhenian coast of Sicily and Calabria drift nets called "Ferrettara" are still widely used to catch small pelagic species. However for the technical characteristics these nets are very similar to the illegal drift nets called "Spadara nets" targeting swordfish. The use of the "Ferrettara" is reported to lead to the catch of turtles, cetaceans or sharks but no assessment of the impact of these fisheries has been undertaken. These fisheries are continuing under derogation from the Italian government but no mitigation measures have been put forward.
- IFREMER in France along with the industry are continuing to do extensive testing of acoustic deterrent devices in French pelagic and gillnet fisheries. The results have been mixed but reductions in cetacean bycatch of between 40-60% have been observed in the bass fishery.
- A new long range acoustic deterrent device has been developed by Germany and Denmark. The device has a detection distance of 400 m and is now being used by the Danish and German authorities to monitor pinger usage in the Baltic. Since the adoption of this device several Russian gillnet vessels have been warned over failure to use pingers, which are compulsory in the Baltic to protect harbour porpoises.

Development of New Fisheries

Several new fisheries have been reported in 2009. Most of these fisheries are for pelagic species and are potentially at a large scale. There is also continued testing of pots as a means for targeting fish although the indications are that these fisheries are still not economically viable in most cases.

Examples of new fisheries are reported as follows:

- Up to 17 Icelandic pelagic trawlers that were targeting capelin before this fishery was closed have developed an experimental fishery for Pearlsides or Mullers bristlemouth (*Maurolicus muelleri*). Catches have initially been poor (> 700 tonnes in a trip) as the fish is only 4 cm. The fishing gear need to be developed further if this fishery is to continue but the motivation is high as the capelin is closed.
- Up to 8 Irish vessels have continued to exploit boarfish and landings in 2008 were estimated at around 10 000 tonnes at a value of over €2 million.

All of the catch is being processed as fish meal as it has a very high oil content. No assessment of the potential impact of this fishery has been carried out but it has diverted effort from the blue whiting fishery for which Ireland had a much reduced quota in 2008/2009.

- There has been increased interest in Norway in the exploitation of marine zooplankton such as copepods and krill. Several novel methods have been tested using air bubbles to lift Calanus to the sea surface to be skimmed by oil spill recovery type equipment and also by concentrating Calanus closer to the surface to be collected by a small mesh trawl with reduced opening area.
- A new trammel net fishery for the shrimp species *Metapenaeus affinis* has been developed in the Bay of Izmir, on the Aegean coast of Turkey. This species is an alien species to the areas but has a higher commercial value and longer fishing season so has now become more important that the native Mediterranean prawn (*Melicertus kerathurus*).
- There has been limited testing of pots to target cod in the Baltic Sea by Germany. The results, however, have been very disappointing with very low catch rates and this work has been abandoned.
- Trials in France with fish pots in the Bay of Biscay have been less successful. Catches have been dominated by conger eels which have a low value. Experiments with floating pots are underway to solve this problem. Encouraging trials with *Nephrops* traps are still going on in the Bay of Biscay.

9.4 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:

WGCHAIRS	WGWIDE
WGNSSK	AFWG
WGCSE	HAWG
WGHMM	WGECO
WGDEEP	WGMME
WGBFAS	WGNEW
WGSE	SGBYC
WGNEW	WGANSA
GFCM	

9.5 Recommendations

1) WGFTFB will 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 recommend that a timetable for provision of this information to the Assessment Working Groups be drawn up 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.

3) WGFTFB will continue to provide information to GFCM in the Mediterranean and extend this to include non-EU and non-ICES affiliate countries where possible.

10 ToR b) Seine net fisheries

10.1 General Overview

The fishing method of seining is reputed to have first been carried out by a Danish fisherman, 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 fishermen developed a different method of seining which dispensed with the need for an anchored dhan, but which utilised the thrust of the vessel's propeller to balance the drag of the gear as it was slowly winched aboard. Over the years Scottish seining, or fly-dragging, 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 fishermen globally.

A WGFTFB Topic Group was formed to address this ToR. This Topic Group met from 20 to 22 May in Ancona. Initially the ToR was introduced by the chair along with Harldur Einarsson of Iceland. Following the discussions of the Topic Group the conveners reported back to plenary WGFTFB.

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 and with the outline of the report now in place (see below); the goal is to have written drafts of many chapters completed by the next WGFTFB meeting. Therefore during 2009 the participants focused their attention on the first two Terms of Reference. In 2010, the topic group will conduct further discussions, addressing the remaining ToRs, conduct final editing, and clarify the recommendations given.

The main chapters for the report agreed are as follows:

- Background / Introduction
- Operation of the gear
- Identify all seine net fisheries globally

- Positive Aspects
- Negative Aspects
- Review methods for determining selectivity
- Regulations
- Recommendations

10.2 Terms of Reference

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

a) 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.

b) 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.

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

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

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10.4 General issues

10.4.1 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 although this is a work in progress that will be updated in 2010.

Table 3. Summary of Seine Fisheries by Country

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 (2009)	23 m / 555 hp	Fly dragging (Scottish seining)	Haddock, Whiting, Cod, Hake
France	Celtic Sea, English Channel, North Sea, Bay of Biscay	3	24-35 m / 600-1000 hp	Fly dragging (Scottish seining)	Red Mullet, Squid, Whiting, Cod, Hake, Seabass
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	14 (single)	21 m / 620 hp (single)	Fly dragging (Scottish seining)	Cod, Haddock, Whiting
		20 pairs	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 seining) (older vessels)	Plaice, Cod
Sweden	Skagerrak & Kattegat	2	Not specified	Fly dragging	Cod and flatfish
Canada	Fortune Bay	8 (2000)	19m	Fly dragging	Witch Flounder
New Zealand	Haruaki Gulf, Bay of Plenty & East Northland	25 (up to 100 historically)	12-24m	Ancor seining	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

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

- Anchor seining
- Scottish seining (Fly-dragging)
- Pair seining

Purse seining is not discussed under this term of reference.

10.4.2 Scottish Seining (Fly-dragging)

Scottish seining is well described by Galbraith and Rice (2004). This fishing method depends on long lengths of rope used, up to three kilometres a side, herding fish into the path of a net as the gear is hauled back slowly. The gear is set roughly in the shape of an isosceles triangle with the dhan, which marks the end of rope first shot and to which the vessel returns to complete the set, as the apex and the net as the centre of the base. Having picked up the dhan the vessel then starts to steam slowly ahead while heaving in both ropes, gradually advancing winch speed as the gear closes to keep the net moving forward at a steadily increasing rate.

10.4.3 Danish Anchor Seine

"Anchor seining", 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 closed entirely by winch. The net is set out from an anchored dhan (marker) buoy. The operation is carried out directly by the main vessel, so called "seiner" or sometimes from an additional smaller boat. First, one drag line is put into the water, then one net wing follows and, while the seiner turns round in a surrounding move, back to the buoy, the setting continue with the bag of the seine, then the other wing, then, finally, the other drag line. Hauling in of the net is carried out using the two drag lines by the boat anchored at the marker; the two drag lines are simultaneously hauled with the help of a rope-coiling machine until the bag with the catch can be taken on board the vessel.

10.4.4 Pair Seine

Pair seining is a technique that developed in Scotland as a more efficient and simpler method than traditional single boat seining. As reported by Galbraith and Rice (2004), pair seining involves a second vessel picking up the dhan and both vessels towing the gear in the manner of a demersal pair trawl before hauling as per single seining. After one vessel shoots its net the bridles are passed across to the partner with the aid of a messenger and connected to the heavy sweep wire. Both boats pay out wire and rope as they steam ahead to take up towing positions. At the end of the haul both boats come together again and the previously transferred bridle is passed back to allow the first vessel to complete hauling operations. This procedure substantially increases the area of seabed swept by the gear and can improve catches when fish concentrations are small and widely dispersed. However, pair seines are now commonly rigged, shot and hauled similarly to pair trawls, with wire towing warps and sweeps in front of 880 m of polypropylene seine net combination rope per side. Vessels maintain station up to 0.5 nautical miles apart while towing.

10.5 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 1, seining scored favourably compared to other active fishing methods such as trawls.

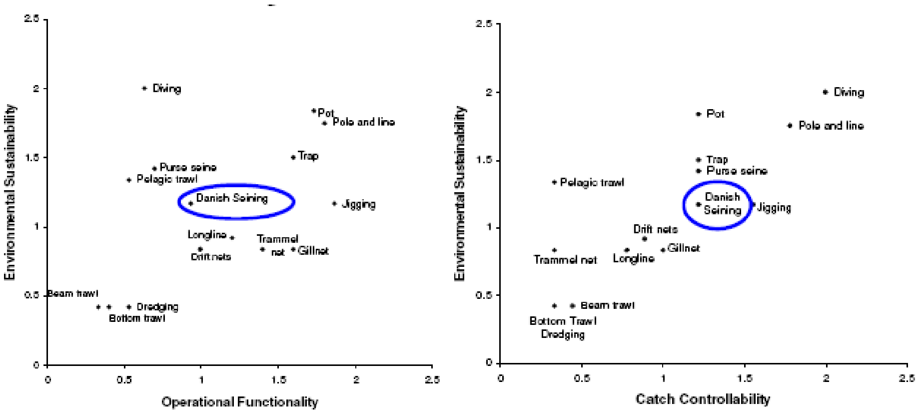

Figure 1. Relationship indices of "Environmental Impact", "Operational Functionality" and "Catch Controllability" for different fish capture methods (ICES, 2006a)

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 Danish/Scottish seine fisheries there are concerns about levels of discarding and high-grading as seine netters aim to maximise 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.

10.5.1 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 close 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 was 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 2 below.

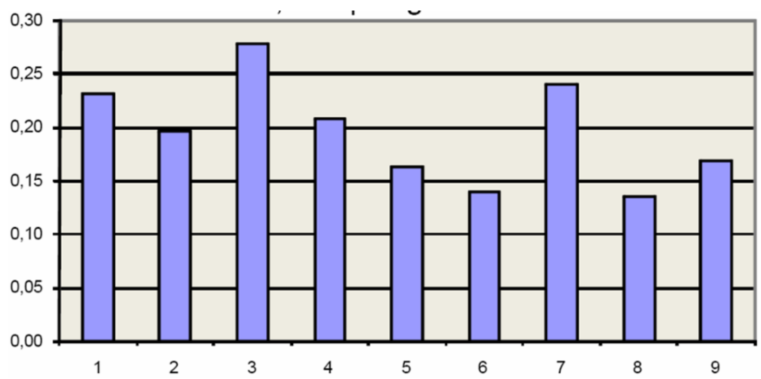

Figure 2. Fuel consumption from nine Icelandic seiners Iceland (Rúnarsson, 2008)

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 1990–1997, 2000 and 2008 (Rúnarsson, 2008)

TYPE OF FISHING BOAT	LITER 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 summarises 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 data sets show seine netting to be a fuel efficient method compared to other active fishing methods.

10.5.2 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. 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, byproduct/ bycatch species, protected or charismatic species, habitats and communities were classified as requiring some additional analysis or management response. When compared to the Danish seine gear, 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.

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.

10.5.3 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 fishermen 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 swim bladder gas in the body cavity.

10.5.4 Selectivity/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 at 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 Danish seine fisheries in Iceland. A later Icelandic study reported by Einarsson (2008) showed discard rates in Danish seine fisheries in terms of weight of cod and haddock over the period 2001–2007 had the highest (~12%) and lowest (0%) rates of measured discard rates of any fisheries in Iceland. 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.

With respect to selectivity data for 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 of was problematically given the way seine net gear is operated. Codend covers (Coull and Robertson, 1985), alternate haul (Anon., 1990; Anon. 1991) and trouser codends (Anon., 1991; Anon; 2006) have all been used to measure selectivity but none have proven to give completely satisfactory results.

A number of different selectivity devices have been tested to improve seine net selectivity in addition to simple increases in mesh size (Spingle 2001). These include the use of square mesh panels (Arkley, 1990; Ashcroft, 1991; Anon., 2002, Anon., 2003), grids (ICES, 1998; Anon., 2008) and coverless trawls with reduced top sheets (Anon., 1997). 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.

The group will carry out a more comprehensive review of methods for measuring and improving selectivity in 2010.

10.5.5 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 summarised the major changes as follows:

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

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 with upper/lower panels, fishing squares and lateral lastridges. Two specific types of gear are common:

- Clean ground seine nets which are typically larger than trawl nets although lighter in construction having rope foot ropes (grass ropes). French and Dutch vessels tend to use small rubber disc footropes. A slight 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 ground rope 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 ground rope 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 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 3. Examples of Grassrope and Rockhopper Footropes from seine nets

Other than the Icelandic study reported in section 10.5.2, no other specific studies looking at the impact of seine net groundgear on the seabed were found.

Seine Rope

Mot seine net vessels work up to 15 coils (each 220 m long) per side of polypropylene ropes, lead cored to ensure quick sinking and good bottom contact. Seine rope is usually of 3-strand construction and is made up of PP rope with a lead core. Seine rope can be anything from 18 mm – 55 mm on the largest vessels with weights of 74 kg/220 m up to 200 kg/220 m. 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 40 mm diameter combi-seine rope weighing 372kg/220 m. Again similar motivations with regard maintaining bottom contact and life span 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.

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 and 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 revolutionalised 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 over-running. 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, enabling 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.

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 7 below summarises the range of sensors now available.

Table 7. 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 head rope to both wings. Main sensor mounted on head rope, 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 echo sounder principle)	Can be mounted on ground rope to detect bottom contact.
Seine Sounder	Depth and Height sensor combined	Depth and Height sensor combined

Pair seining & Tow-Dragging

Over the last number of years there has been a steady switch in Scotland from single seining to pair seining. Pair seining is recognised 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 and warp. The gear is also towed for much longer than a single seine and the operation is 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 and 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 recognised that the increased move from seining to pair seining represents an increase in effort in comparison to single seining. It also felt that pair seining is very similar to pair trawling and therefore may have an increased bottom impact in comparison to traditionally seining. Similarly the move to tow-dragging also represents a potential increase in efficiency. This issue will be considered further by the group in 2010.

Dual Purpose Vessels

Most Dutch seiners (9 out of 10) have been equipped with both trawl winches and seine reels, enabling 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 wintertime with trawling for plaice in the North Sea during the 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.

10.6 Conclusions

An initial assessment of seine netting has been undertaken by the Topic Group and identified some positive and negative effects of this fishing method. From the initial 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. 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 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.

10.7 Recommendations

The topic group has outlined some initial recommendations but agreed that these need to be discussed further next year when a more comprehensive review has been carried out. These recommendations are as follows:

1) Carry out a comprehensive review to substantiate the environmental friendliness of seining including ecological impact of seining on seabed habitat and discarding levels in seine net fisheries.
2) Review the results of selectivity experiments with seine net gear and assess methodology for measuring the selectivity of seine nets, which has proven problematically in the past.
3) Describe factors that influence fishermen into switching between seining & other fishing methods and in particular pair seining or trawling.

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10.9 Individual Presentation

10.9.1 Review of Seine Net Seminar held in Iceland 2008

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Abstract

In May 2008, a two day International seine net seminar was held in Keflavik Iceland. Host organised by the Icelandic Federation of Seine Netters. Several presentations were given, mainly from netmakers and seine net skippers from Iceland, Norway and Scotland. This review highlights two interesting points from this seminar regarding fuel consumption and bottom impact. Guðbergur Rúnarsson from Federation of Icelandic Fish Processing plants gave some interesting results on fuel consumption of seine nets boats and compared this data to fuel consumption from boats using other types of fishing gear. His main finding was that seine net boats use an average of 0.2 litres/kg catch while trawler use near 0.42 litres/kg catch and longliners 0.15 litres/kg. It was pointed out that beam trawlers in the North Sea used approximately 2.5 litres /kg catch.

A review of gear impacts emphasized that seine nets are essentially “light” gears and likely to have less bottom impact than trawls. In one haul of a seine net in Icelandic waters, an average of 2.25 km^2 is fished, but repeated shooting with seine nets on the same ground can possibly have effects on bottom fauna but at what level and for different bottom types are not known. Discard rates in weight of cod and haddock from an Icelandic study (2001–2007) showed that seine netters had the lowest (~0%) and the highest (~12%) measured discard rates in Iceland.

The conclusion of this short overview is that this fishing method is considered more environmental friendly than some other fishing methods but needs to be controlled particularly with respect to discarding and high grading.

11 ToR c) Discard policy and framework

11.1 General Overview

In 2008 the European Commission focused on mitigation of discards associated with a number of key fisheries in community waters. Part of this process had identified candidate technical measures suitable for these fisheries which would achieve measurable targeted reductions. The target discard levels were to be fishery specific and w reduced over a specified period so as to achieve a Maximum Allowed Bycatch Limit (MABL). In an EU non-paper “On the implementation of the policy to reduce u n-wanted bycatch and eliminate discards in European fisheries” the Commission identified two key fisheries as:

- Bottom trawl fisheries in ICES area VII targeting *Nephrops* and
- Beam trawling for flatfish in ICES areas IV and VIId

11.2 Terms of Reference

Arising from this non-paper and the definition of MBAL targets for these fisheries it was initially proposed that a WGFTFB topic group of experts would be formed with the following ToRs:

a) to review and appraise the current selectivity characteristics of the gears used in the Area VII *Nephrops* trawl fisheries and Beam trawl fisheries for flatfish in ICES areas IV and VIId; and

b) to propose potential gear modifications that could contribute to the future technical conservation measures needed to achieve the targets proposed by the European Commission, while also taking into account fish survival from such gear modifications.

11.3 General Issues

During early 2009 it became apparent that the EU had decided to abandon this proposed approach for the two fisheries indicated although formal notification of this was not received until April 2009. It was therefore decided that there was little point in proceeding to address this ToR at the WGFTFB meeting as there was no alternative approach being proposed by the EU.

However, it emerged that the issue of discarding had been raised at the sixty-third session of the United Nations General Assembly and also at the twenty-eighth session of the Committee on Fisheries of the Food and Agriculture Organization of the United Nations[1] (COFI) during 2009. Frank Chopin of the FAO gave a presentation to plenary WGFTFB on what was discussed:

Background

The FAO Code of Conduct for Responsible Fisheries (CCRF) calls for sustainable use of aquatic ecosystems and requires that fishing be conducted with due regard for the environment. The CCRF also promotes the maintenance, safeguarding and conservation of biodiversity by minimizing fisheries impacts on non-target species and the ecosystem in general. However, there is growing concern that the combined effect of failing to minimize the catch of undersized fish of target species, non-target fish species and non-fish species is threatening the long-term sustainability of fisheries, the maintenance of bio-diversity and contributing to food insecurity, thus affecting the livelihoods on those dependent on fish resources.

Calls for action on bycatch and discards have been raised at the United Nations General Assembly. Most recently, the sixty-third session of the UNGA urged States, subregional and regional fisheries management organizations and arrangements and other relevant international organizations to reduce or eliminate bycatch, catch by lost or abandoned gear, fish discards and post-harvest losses, support studies and research that will reduce or eliminate bycatch of juvenile fish, and consider the development of standards for reducing or eliminating discards. It is proposed to do this through the development of an international plan of action, at the twenty-eighth session of the Committee on Fisheries of the Food and Agriculture Organization of the United Nations[2].

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[1] A/RES/63/112

[2] A/RES/63/112

COFI and FAO have also identified bycatch and discards as serious concerns in many fisheries and as threats to long-term capacity to provide both food and a source of livelihood. In 2004, FAO estimated that discard global catch was approximately 7 million tonnes[3]. However, estimating global bycatch has proved difficult for a variety of reasons and it may well be in excess of 20 million tonnes. While there is evidence that discards have reduced over time, species and sizes of fish that were previously discarded are now being retained in some regions to support a growing demand for aquafeeds[4]. Past efforts taken by FAO to address this issue have included development of International Plans of Action for sharks[5] and seabirds[6], technical guidelines to reduce marine turtle interactions with fisheries. Despite these efforts, problems persist with high level of bycatch and discards in many fisheries around the world including the capture of juveniles of economically valuable and ecologically important fish.

At the twenty-eighth session of COFI in 2009, FAO reported on bycatch and discards within the context of IUU fishing and reiterated the concern that in poorly managed fisheries, unreported and unregulated (i) landings of bycatch, (ii) discards, and (iii) pre-catch losses[7] are issues of major concern[8]. At the proposal of Norway, COFI agreed that FAO should develop International Guidelines on bycatch management and reduction of discards through the process of an Expert Consultation followed by a Technical Consultation.

Accordingly, FAO is planning to organize an Expert Consultation to develop a draft text on "International Guidelines on bycatch management and reduction of discards". The draft text prepared by this Expert Consultation will form the basis of a Technical Consultation to be convened by FAO at the earliest possible opportunity.

Inputs

The main input will be a zero draft text of the International Guidelines on bycatch management and discard reduction which will be distributed at least one month prior to the consultation.

Output

A single report titled "Draft text - International Guidelines for bycatch management and reduction of discards".

Participants

Participation is by invitation only, following FAO relevant procedures. A limited number of experts will be invited by FAO in their individual capacity from a range of disciplines (technical, legal, policy, etc.) and a range of countries and affiliations.

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[3] FAO. 2005. Discarding in the world's marine fisheries: an update, by K. Kelleher. FAO Fisheries Technical Paper No. 470. Rome

[4] SOFIA 2006

[5] http://www.fao.org/fishery/ipoa-sharks/en

[6] http://www.fao.org/fishery/ipoa-seabirds/en

[7] refers to fish and other animals that are killed but not landed through encountering the fishing gear (including ghost fishing)

[8] COFI/2009/6

Language

Based on the concurrence of the participants, the Expert Consultation will be conducted in English. Experts must agree in advance of the meeting that they are prepared and able to work only in English.

Date and Venue

The Expert Consultation will take place in late 2009 in Rome, Italy.

Discussion

A discussion was held at the plenary session of WGFTFB as to the role and involvement of WGFTFB in this process. Frank Chopin stated that while it was highly likely that some members of WGFTFBwould be involved in the Expert Consultation, this was global problem that required expertise from around the world. He also felt it unwise for WGFTFBto consider what would be required in drawing up international guidelines given this is only at a preliminary stage within FAO. He did feel, however, it may be appropriate to consider the guidelines produced in 2010 depending on progress.

WGFTFB concluded from this discussion that the issue of discarding and bycatch was of critical importance to all WGFTFB members and must remain high on the agenda in developing future work plans for the EG under the ICES Science Plan. Further discussion as to what format this should take, however, is required with input from all participants.

12 ToR d) Technical issues relating to the Mediterranean

12.1 General overview and presentation of main findings

This ToR was introduced by Antonello Sala, Alessandro Lucchetti (CNR-ISMAR, Italy) and Jacques Sacchi (IFREMER, France) at the 2008 WGFTFBmeeting in Faroe Islands. An overview of the topic was given by Antonello Sala to the whole WGFTFBat the start of the 2009 meeting.

12.2 Terms of Reference

a) review progress with better developing scientific collaboration of WGFTFB with GFCM on fishing technology issues in the Mediterranean; and specifically

b) review new research with 40 mm square-mesh codends recently introduced into EU legislation for the Mediterranean;

c) assess the efficacy of 40 mm square-mesh codends in terms of improved selectivity and fish survival;

d) identify whether from a technical perspective the regulation needs to be amended i.e. twine material, meshes in the circumference.

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12.4 Overview

The Group met on 20, 21 and the morning of 22 of May 2009 in Ancona. Conveners: Antonello Sala and Huseyin Ozbilgin. A total of 19 scientists participated in this Topic Group.

12.4.1 Review new research with 40 mm square-mesh codends recently introduced into EU legislation for the Mediterranean

A critical analysis of selectivity research allowed a number of main factors affecting the trawl selectivity in Mediterranean to be identified. It was not only a mere review of the available papers, but also an attempt to describe how some technical parameters (e.g. mesh size, mesh configuration, twine diameter, mesh hanging ratio) affect the codend selectivity.

The group found the following:

- A highly significant effect of mesh configuration on L50. This effect is higher in round fish such as hake probably due to fish morphology.
- Problems arising from the use of different terminology by the different authors.
- Data missing for some important parameters: twine diameter, codend circumference, extension description.
- The parameter Selection Factor is independent of codend mesh size but it depends on the same parameters and needs to be further investigated.

The group also discussed the effect of mesh configuration and mesh size on codend selectivity considered in a recent study in Sicilian waters (Lucchetti *et al.*, 2008). In this experiment four codends with two different mesh sizes across two mesh configurations have been tested; mesh size and mesh configuration were included as explanatory variables in the statistical analysis. This study indicates the advantages/disadvantages of using e.g. a 40 mm square-mesh codend instead of 50-mm diamond mesh codends as requested in the new Council Regulation (EC) No 1967/2006. From the literature it is clear that the increase in mesh size produces both an incremental change in L50 but an unwanted incremental change in SR. The results attained in the present study allow the conclusion to be drawn that the use of 44 mm square-mesh codend results in L50 similar to that of the 54 mm diamond-mesh codend but a narrower SR.

12.4.2 Assess the efficacy of 40mm square-mesh codends in terms of improved selectivity and fish survival

The only relevant data on the survival of fish escaping from trawl codends in the Mediterranean was obtained from unpublished data from Ege University, Turkey (Düzbastılar, pers. comm.). This work was reviewed by members of WGFTFB and WGQAF who commended the staff and students of Ege University for undertaking this important and complex work. On the whole, the work was recognised as being conducted to a good scientific standard using sound and proven protocols. However, a potential flaw in the sampling protocols was identified that may have confounded the results. The collection of samples was not randomised; instead each of the samples of escaping fish for each sampling category (controls, diamond mesh escapees and square mesh escapees) were collected in groups over a two day period, i.e. three control hauls/samples, then three square mesh hauls on the first day, followed by three diamond mesh hauls on the second day. Therefore, the apparent mesh shape effect observed on mortality may also be confounded with a possible temporal effect. In order to have reasonable scientific confidence in these observations this work will need to be repeated, with improved sampling protocols. Other suggested amendments to the protocols and data analysis were conveyed to Ege University.

12.4.3 Identify whether from a technical perspective that the regulation needs to be amended

The group identified and highlighted some potential problems and drawbacks with EC Reg. 1967/2006 concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. This Regulation as formulated could lead to misunderstanding and different interpretations between countries. Furthermore there are some mistakes in the translation from English to different languages. Finally the many derogations introduced could make it difficult to endorse the Regulation and very difficult for it to be applied (it could be very complicated also for fishery inspectors to control and to enforce the law). Moreover, the complexity of the Mediterranean fisheries, in terms of diversity of fishing gears and practices, together with its economic structure, does not enable fishermen to be flexible, adapt quickly and to easily accept undesired effects of external factors, including management measures. The document intends to open a dialog between fishing gear technologists on the technical aspects and definitions of bottom trawling.

In this respect the group outlined the technical issues that need to be investigated in the future as well as possible suggestions for solutions to fishery managers.

In particular Article 9 of EC Reg. 1967/2006 reports that:

i) The use for fishing and the keeping on board of a towed net, a surrounding net or a gillnet shall be prohibited, unless the mesh size in that part of the net having the smallest meshes complies with paragraphs 3 to 6 of this Article.

ii) The mesh size shall be determined by the procedures specified in Commission Regulation (EC) No 129/2003 (1).

iii) For towed nets, other than those referred to in paragraph 4, the minimum mesh size shall be:

iv) until 30 June 2008: 40 mm;

v) from 1 July 2008, the net referred to in point 1 shall be replaced by a square-meshed net of 40 mm at the codend or, at the duly justified request of the ship owner, by a diamond meshed net of 50 mm.

Annex II

Trawl nets

Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawl nets along with the maximum number of nets in multi-rig trawl nets shall be adopted, by October 2007, in accordance with the procedure laid down in Article 30 of this Regulation.

12.5 Discussion and conclusions

12.5.1 Review new research with 40 mm square-mesh codends recently introduced into EU legislation for the Mediterranean

The selectivity of 40-mm diamond mesh codend has been reported to be rather poor because a large proportion of the codend catch is immature and smaller than the minimum landing size or first maturity size. For all the species considered in research completed, the mesh shape (i.e. diamond or square) plays a role which is as important as the actual mesh size. However, square meshes were found to be unsuitable for flat and/or deep-bodied fish as these species escape more readily from diamond meshes. In particular in this study, better values of L50 were found for all species with the exception of scaldfish. The group confirmed that the species analysed, apart from most of the flatfish species, make the best use of the square mesh opening, either because of their body shape or because they force their body to penetrate through the mesh. In conclusion, enforcement of installation of square-mesh codends in Mediterranean demersal trawl fisheries can be a suitable technical solution to decrease the capture of immature individuals of roundfish species but not flatfish or deep-bodied species.

12.5.2 Assess the efficacy of 40 mm square-mesh codends in terms of improved selectivity and fish survival.

Members of WGFTFB and WGQAF then collated data describing the length frequency characteristics and codend selection of Red Mullet (*Mullus barbatus*) from different regions of the Mediterranean region: Izmir Bay, Marmara Sea, Iskenderun Bay and the Adriatic Sea. Using methods described in Ferro *et al.* (2008), these data and the escape mortality data in Düzbastılar (pers. comm.) were analysed and estimates of the total (partitioned) fishing mortality for a theoretical trawl fleets in each region using diamond (nominal 40 mm and 50 mm) and square (40 mm nominal) mesh codends.

In summary, for Red Mullet in the Mediterranean Sea there is preliminary evidence to suggest that the magnitude of escape mortality could be sufficiently high to counteract the benefits of discard reductions through the proposed introduction of new mesh size regulations in 2010; thus leading fisheries managers to overestimate the conservation benefits of these new technical measures. In areas where the exploited population includes high proportions of juvenile fish (which can be more susceptible to escape mortality – Breen *et al.*, 2007; Suuronen, 2005), the proposed increases in gear selectivity could lead to substantial increases in total fishing mortality, despite apparent decreases in landed and discarded catch, because of disproportionately large increases in the associated escape mortality. This is particularly likely if fishing effort is allowed to increase in these areas to accommodate for the loss of catch due to the increased size selectivity of the trawl codends.

12.5.3 Identify whether from a technical perspective that the regulation needs to be amended.

The group identified and highlight the following parts of the Regulation that could lead to ambiguous interpretations.

In Article 9, the statement "at the duly justified request of the ship owner" is unclear.

In Annex II the lack of clear indication regarding the groundrope characteristics (weight, rigging, rockhopper, materials etc.) could lead to uncontrolled and unregulated impact on the sea bottom. Furthermore the impact of multi-rig trawl nets in the Mediterranean is poorly investigated. The maximum number of nets in multi-rig trawl (i.e. twin trawl, rapido trawl) is not defined in the Regulation and there are indications that several fishermen in Italy have shifted their activity from traditional bottom trawl towards twin trawls.

Technical specifications, which limit the maximum dimension of the trawls in Mediterranean, are not yet defined because of insufficient information.

12.6 Recommendations

1) WGFTFB recommend identifying from a technical perspective that Article 9 of Regulation 1967/2006 need to be amended. In the case of Annex II it is recommended Mediterranean workshops to address technical specifications limiting the maximum dimension of trawl nets along with the maximum number of nets in multi-rig trawls are required.

2) WGFTFB recommend that investigating the survival of fish being discarded and escaping from fishing gears in the Mediterranean should be highlighted as a research priority for all ICES member states.

3) WGFTFB recommends a workshop should be held to develop methods for investigating the escape and discard mortality of key species in the Mediterranean (Conveners: to be decided). The workshop would bring together essential areas of expertise, including: fisheries biologists; gear technologists and researchers specialising in escape mortality experiments (both lab & field based). The objectives of the workshop would be to:

   a) Identify "Critical" species/fisheries (from amongst economic and ecologically important Mediterranean species) that - based upon a knowledge of their biology, distribution (temporal & spatial) and exploitation - are likely to be susceptible to injury/stress and/or have juvenile populations exposed to fishing activity;

   b) Define protocols for investigating at a preliminary level the susceptibility of these "Critical" species to capture stressors/injuries;

   c) Define protocols for dedicated survival experiments that will provide usable estimates of mortality for inclusion in fisheries management;

   d) Define protocols for including discard and escape mortality data into current fisheries management processes in the Mediterranean;

   e) Recommend research priorities for survival experiments in Mediterranean species/fisheries defined as "critical" in a)

4) WGQAF should be requested to coordinate research activities in this important area of research and report progress to ICES.

5) WGFTFB recommend that the effect on selectivity of the use of strengthening bag in Mediterranean fisheries should be investigated. In addition further research should be carried out on the impact of multi-rig trawl and

based on a precautionary approach some restrictions should be considered (i.e. closed areas or seasons).

6) WGFTFB recommend that the biological, ecological, economical/social aspects of the 50 mm diamond mesh compared to 40 mm square mesh in multi-species fisheries are not fully understood and should be investigated.

12.6.1 Selected publications related to trawl selectivity in Mediterranean.

Aydın C, Tosunoglu Z, Tokaç A. 2008. Sorting grid trials to improve size selectivity of red mullet (Mullus barbatus) and annular sea bream (Diplodus annularis) in Turkish bottom trawl fishery Journal of Applied Ichthyology, 24(3): 306-310

Kaykaç, H., 2009. Effects of mesh configuration on the selectivity of demersal trawl codends for *Nephrops* norvegicus (Linnaeus, 1758) (Decapoda, Nephrophidae)". Crustaceana (Accepted Paper)

Kaykaç H, Tokaç A, Özbilgin H, 2009. Selectivity of commercial, larger mesh and square mesh trawl codends for deep water rose shrimp Parapenaeus longirostris (Lucas, 1846) in the Aegean Sea. Scientia Marina 73(3): 597-604.

Lucchetti A, Palumbo V, Perdichizzi F, Rinelli P, Sala A, 2008. EC REG. 1967/2006: is square-mesh better selective than larger mesh-size? Comparative experiment in Sicilian trawl fisheries. Biol. Mar. Medit., XV(1): 338-339.

Ordines F, Massutí E, Guijarro B, Mas R, 2006. Diamond vs. square mesh codend in a multi-species trawl fishery of the western Mediterranean: effects on catch composition, yield, size selectivity and discards. Aquat. Living Resour. 19: 329-338.

Özbilgin, H., Tosunoğlu, Z., Tokaç, A., and Metin, G. 2007. Seasonal variation in the trawl codend selectivity of picarel (Spicare smaris). – ICES Journal of Marine Science, 64: 1569–1572.

Sala A, Priour D, Herrmann B, 2006. Experimental and theoretical study of red mullet (Mullus barbatus) selection in codends of Mediterranean bottom trawls. Aquat. Living Resour. 19: 317-327.

Sala A, O'Neill FG, Buglioni G, Lucchetti A, Palumbo V, Fryer RJ, 2007. Experimental method for quantifying resistance to the opening of netting panels. ICES Journal of Marine Science 64: 1573-1578.

Sala A, Lucchetti A, Buglioni G, 2007. The influence of twine thickness on the size selectivity of polyamide codends in a Mediterranean bottom trawl. Fisheries Research, 83: 192-203.

Sala A, Lucchetti A, Piccinetti C, Ferretti M, 2008. Size selection by diamond- and square-mesh codends in multi-species Mediterranean demersal trawl fisheries. Fisheries Research, 93: 8–21.

Tokaç A, Özbilgin H, Kaykaç, A, 2009. Alternative codend designs to improve size selectivity for Norway lobster (*Nephrops* norvegicus) and rose shrimp (Parapeneaus longirostris) in the Aegean Sea. Crustaceana 82 (6): 689-702.

Tokaç A, Özbilgin H, Kaykaç, H. (in press). Selectivity of Conventional and Alternative Codend Design for Five Fish Species in the Aegean Sea. Journal of Applied Ichthyology.

12.7 Abstracts of the Presentations

12.7.1 EC Reg. 1967/2006: is square-mesh better selective than larger mesh-size? Comparative experiments in Sicilian trawl fisheries

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Abstract

We investigated the effect of mesh configuration and mesh size on the codend selectivity of the species (*Aristaeomorpha foliacea)*, (*Parapenaeus longirostris)* and (*Mullus barbatus)*, commonly captured in the Sicilian trawl fisheries. For each mesh configuration, square and diamond mesh, two nominal mesh sizes of 44 mm and 54 mm were tested. For both the species, the mesh configuration plays a role which is as important as mesh size.

12.7.2 Preliminary data on survival of Norway lobster (*Nephrops norvegicus*) escaping through standard diamond and square mesh codends

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Abstract

The survival of *Nephrops* escaping through standard 70 mm diamond codends and square mesh codends 55 mm was investigated onboard a commercial trawler off the Portuguese coast. Individuals in test and control (caught with traps) groups were assigned a vitality score, examined for assessment of physical damages and sampled for physiological stress parameters during the different survey phases: arrival on deck, placement in cages that are released at sea, and finally, cage haul-up on board. A positive effect of using square mesh in survival was observed in aggregated data, with average figures attaining more than 30% for individuals escaping from square mesh codends.

12.7.3 Size selectivity of diamond (PA) and square (PE) mesh codends for commercially important fish species in the Antalya Bay, eastern Mediterranean

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Abstract

Size selectivity of 40 mm PE square mesh codend was compared to the 44 mm PA diamond mesh codend under commercial conditions in the demersal trawl fishery off Antalya Bay, eastern Mediterranean between 10 and 22 July 2007. Data were collected using the covered codend technique and analyzed by a logistic equation with maximum likelihood method. Changing the mesh shape from diamond to square increased the mean 50% retention lengths (L50s) of red mullet (*Mullus barbatus*), picarel (*Spicara smaris*) and bogue (*Boops boops*), but decreased the selection range (SR). These values were reversed for common pandora (*Pagellus erythrinus*) due to its body shape. For large-eye dentex (*Dentex macrophthalmus*) and axillary sea bream (*Pagellus acarne*)

the mean L50 and SR values were found to be 9.6 and 11.8, and 2.4 and 2.4 cm, respectively in only DM44PA codend. For golden banded goatfish (*Upeneus moluccensis*) these values found only for SM40PE as 15.0 and 2.7 cm, respectively. Results show that square mesh gave higher selectivity for most of the Mediterranean fish species and suggests that regulating mesh size by requiring square mesh openings during trawling is essential for the release of immature individuals.

12.7.4 Effectiveness of a sorting grid on fish separation and size selectivity for the deepwater rose shrimp in Turkish bottom trawl fisheries

Aydın Celalettin, Tokaç Adnan, Aydın İlker, Erdoğan Uğur.

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Abstract

This study had two main objectives. The first was to evaluate the effectiveness of a sorting grid, 20 mm bar spacing, for species separation (sorting fish from deep water rose shrimp). The second was to compare the combined selection of the grid with 44 mm diamond (44D) and 40 mm square mesh codends (40S). The experiments were conducted on 17–24 August 2008 in the international waters of the Aegean Sea. The trials were carried out on the commercial trawler "Hapuloğlu" (23.8 m, 550 HP) at a mean depth of 369 m (between 240–460 m). The average towing duration of a haul and the trawling speed were 3.1 h (1.2–4.3 h) and 2.5 knots (2.4–2.6 knots) respectively. A 20 mm bar spacing grid was used in the first experiment with overall dimensions of 1.50 x 1.0 m in height and width. It was mounted in a 5 m long and, 200 mesh extension piece section of 50 mm mesh made in braided polyethylene (PE), which was inserted between the rear panel of trawl and codends at a theoretical angle of 45°. A total of 18 valid hauls (nine; a 20 mm grid with 44D, nine; a 20 mm grid with 40S codends) was performed during more than 50 trawling hours.). There was no significant difference in species selection escapement ratio between the 44D and 40S (P> 0.05). The escapement rate for silver scabbard was the highest of all species being 97% and 96.8% in 44D and 40S, respectively. Hake escapement varied between 63.9% and 82.6%, by number in 44D and 40S, respectively. Greater forkbeard, angler fish, broadtail shortfin and Atlantic spotted flounder escapement varied between 68.6% and 86.3%, by number in 44D and 40S, respectively. In addition to fish separation, this study also aimed to evaluate size selection of 44 mm diamond and 40 mm square mesh codend for the deep water rose shrimp. The L50 values of mean curves for rose shrimp were calculated as 18.9 and 20.5 mm in the 44D and 40S, respectively. Total codend and species catch and towing duration did not have any significant effect on the selectivity of this species ($P<0.01$).

12.8 Abstracts of Posters

12.8.1 Norwegian hooks in the Adriatic longline fishery: a pilot study

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Abstract

The present study reports the results of fishing trials conducted during 2007 in the Southern Adriatic Sea using a commercial longline vessel. The catch efficiency of the

J-shaped hook (i.e., Mustad: Round Bend Sea), commonly used in the Italian bottom longline fishery, was compared to hooks with innovative design used in the Norwegian costal longline fishery (i.e., Mustad: EZ-Baiter, Wide Gap, Wide Gap Eyed). A variant of the traditional J-shaped hook, characterized by an offset-angle (Mustad: Kirby) was also tested. Fishing trials were conducted in areas with two different bottom morphologies (rocky and muddy bottom). The Wide Gap Eyed was found unsuitable for the baiting operations and was finally omitted from the study. The Kirby hook did not seem to improve the catch efficiency and was not further analyzed. The EZ-Baiter and Wide Gap seemed to have the highest catch efficiency in terms of biomass of fish caught and provided the highest income. The EZ-Baiter and Wide Gap hook were more efficient than the Round Bend Sea hook on both bottom morphologies. It was concluded that introduction of the Norwegian hook designs could improve the efficiency and income of the Italian bottom longline fishery without large investments.

12.8.2 Selectivity of 50 mm diamond and 40 mm square-mesh codend for five commercially important species in the Eastern Mediterranean

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Abstract

For the sustainable fisheries in the Mediterranean Sea, a new regulation on the Management of Mediterranean Fishery Resources (CE 1967/2006) was approved by the European Commission, recommending 40 mm square mesh codends or 50 mm diamond mesh codends as a replacement for the current 40 mm diamond mesh codend for trawlers in the Mediterranean Sea. The selectivity of two trawl codends, (1) 50DMC – 50 mm diamond mesh codend and (2) 40SMC – 40mm square mesh codend, was tested for red mullet (*Mullus barbatus*), kırma mercan (*Pagellus erythrinus*), yabani mercan (*Pagellus acarne* Risso, 1826), ısparoz (*Diplodus annularis*) and izmarit (*Spicara smaris*) during 2008, in the İzmir Bay. Selectivity data was collected using the covered codend technique, and analysed by means of a logistic equation with the maximum likelihood method. The selectivity parameters for individual hauls were estimated using the software CC2000, whereas mean selection curve of the codends were estimated by Fryer's model taking into account the between-haul variation using the EC Model software. The main aim of testing these codends was to determine their efficiency in releasing small fishes and reducing discards in demersal trawl fisheries in the İzmir Bay.

Keywords: Codend selectivity; diamond-mesh; square-mesh; Mediterranean fishery; trawl.

12.8.3 Blanket net fishery in Aegean Sea

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Abstract

The blanket net is a traditional fishing method used at the entrance and exit of small bays. It is widely used in the Turkish coasts of the Aegean Sea. The operation makes use of migration of several valuable species such as, grey mullet (*Mugil cephalus*), sea bass (*Dicentracus labrax*). In this study technical details and operational method of the gear are described.

Keywords: Selectivity, trawl, codend, square mesh, the Aegean Sea.

12.8.4 Reducing non-target species in trammel net fishery on sea grass (*Posidonia oceanica*) meadows

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Abstract

Prohibition of both beach and boat seines and trawl fishery in several bays of the Aegean Sea has led to the extensive use of gillnets and trammel nets especially for capturing stripped red mullet (*Mullus surmuletus*). In İzmir Bay, these nets are generally set on the ground called "apoşi" which are areas that border sea grasses populations. Many commercial and non-commercial species are caught in this fishery as it takes place in highly bio-diverse habitats. The discarded crustaceans and gastropods of the catch component have spiny and sharp body structure, and the ability to climb nets and consume captured fish. During this action, they are accidentally caught in the nets. In the present project a guarding net (selvedge) with a higher hanging ratio was inserted between the leadline and the net to block the climbing of non-target species. The preliminary results of this project are presented. It was observed that the trammel nets with guarding net not only reduced discard species, but also avoid damage in the nets, caused by some crustaceans and gastropods. This project is supported by TUBITAK (108Y239).

Keywords: Trammel nets, discard species, guarding net, *Posidonia oceanica.*

12.8.5 Selectivity of diamond and square mesh PA codends for European hake (*Merluccius merluccius*) in the Sea of Marmara

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Abstract

This study investigates the selectivity of square and diamond mesh codends (PA) for European hake (*Merluccius merluccius*) in the Sea of Marmara. Fishing trials were carried out on the research vessel "R/V-S Yunus" in autumn 2006 using a conventional trawl net. Data were collected using the covered codend technique and analyzed by means of a logistic equation with the maximum likelihood method. Fifty percent retention length (L_{50}) values of 40 and 44 square, and 44 mm diamond were 17.4, 19.9 and 17.7 cm, respectively. L_{50} was found to increase with mesh size for the species. Regardless of the mesh shape and size, L_{50} values were substantially lower than the minimum landing size (25 cm according to Turkish Fishery Regulations) of the spe-

cies. Therefore, the current legal minimum mesh size and other codend configurations for demersal trawling are not suitable for the management of the species.

Keywords: Diamond mesh, square-mesh, Sea of Marmara, trawl fishery, *Merluccius merluccius*.

12.8.6 The occurrence of an alien shrimp (*Metapenaeus affinis*) in the Mediterranean artisanal fishery

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Abstract

In 2000 the use of beach seining and trawling was prohibited in the Bay of Izmir, on the Aegean coast of Turkey. Ever since artisanal fishermen have been using static gears such as gillnets and longlines. Trammel nets have been used between May and October for the native Mediterranean prawn (*Melicertus kerathurus)*. In 2008 large numbers of an alien prawn, (*Metapenaeus affinis)*, were caught for the first time in the inner part of the bay. Because of their increased commercial value and longer fishing season than the native prawn, fishermen began to exploit them. The catch per unit effort (CPUE) in fishing trials carried out in April 2008 was 21.8 ± 1.2 kg.

Keywords: artisanal fishery, alien species, *Metapenaeus affinis*, Turkey, Aegean Sea.

13 ToR e) NAFO request on reducing the bycatch of cod

13.1 General Overview

In September 2007, the NAFO Fisheries Commission requested the following scientific advice from the NAFO Science Committee:

"Noting the FC Rebuilding Plan for 3NO cod adopted in September 2007, Fisheries Commission requests Scientific Council to advise, before September 2010, on a range of possible management measures to ensure bycatch of cod is kept at the lowest possible level."

NAFO SC examined the effects of temporal and spatial changes in fishing effort for the yellowtail flounder (*Limanda ferruginea)* trawl fishery and in June 2008 responded to NAFO FC. However, NAFO SC noted that modifications to fishing gears may further reduce the bycatch of cod but did not have the expertise to provide a detailed analysis.

Following an informal request by NAFO to the chair of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), a summary table of current research findings was produced and forwarded to NAFO. On foot of this information, NAFO made a formal request to ICES as below:

Under the terms of the MoU between NAFO and ICES, NAFO SC requested that WGFTFB:

"to advise NAFO SC on appropriate gear modification, or other technical measures relating to fishing gears, that would ensure that the bycatch of cod is kept at the lowest possible level."

At the WGFTFB meeting on 19–22 May an *ad hoc* group of WGFTFB members met to address this request from NAFO chaired by Barry O'Neill, Scotland. The chair of WGFTFB has taken this information and produced this document as an attempt at addressing NAFO's specific request but it should be noted that it may not necessarily reflect fully the views of all the contributors. The full report is given in Annex 8.

13.2 Terms of Reference

Under the terms of the MoU between NAFO and ICES, NAFO SC requested that WGFTFB:

"to advise NAFO SC on appropriate gear modification, or other technical measures relating to fishing gears, that would ensure that the bycatch of cod is kept at the lowest possible level."

13.3 List of Participants

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13.4 General issues

In responding to this request WGFTFB have identified a considerable amount of research work on gear modifications designed to sort cod from flatfish species as well as cod from other species. Gears that size select cod have also been considered. Several gears have been shown to sort cod successfully from flatfish species in the NAFO area 3NO fisheries, while a number of other gear modifications have been shown to reduce cod catches to low levels in other fisheries were cod is a bycatch. In compiling this review, however, it is clear that any gear modification to be adopted must be tailored to the specific fisheries, species composition and gears used in the fishery. It is also evident that all of these gears have limitations and potential disadvantages.

A review of cod and flatfish behavior has revealed that differences between cod and other species do exist, either in terms of natural separation or in their reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations in all of the work reviewed but it is worth noting that from the extensive video observations made by different researchers, cod do not try to display active escape activity and remain calm and quite sedentary once inside trawl nets. This in itself makes releasing them difficult without the added complication of separating them from other species.

From the gears reviewed there are a number of trawl designs such as the Faroese cutaway trawl, Ribas trawl, US Topless trawl, Danish Selective Flatfish trawl as well work with beam trawls in the North Sea that have adopted the same basic design principle of providing cod an escape route in the front section of the trawl. This has been achieved by either removal of the top sheet of the trawl and extension of the headline back behind the ground gear or alternatively by replacing the netting in the top sheet sections with very large mesh or rope panels. The results from these experiments seem quite variable with considerable haul to haul variation but reductions of cod of between 25% and 80% have been observed. In most of these trials reductions of have been across all size classes, although in the Danish flatfish trawl, were mainly for cod < 35cm. In some of these trials there has been a consequential reduction in flatfish catches. In the case of the US Ribas and Topless this was 30%–56% for yellowtail and winter flounder above marketable size and between 75% and 82% for undersize flounder. Diurnal effects were also noted in these trials, with night tows resulting in the highest reductions in yellowtail flounder catches. Conversely in the other trials, mainly carried out in European fisheries, catches of target flatfish species such as lemon sole, plaice, dab and sole, any reductions in catches were found to be negligible, suggesting possible differences in behaviour between flatfish species. Significant losses of other marketable species such as haddock, whiting and monkfish were noted in most trials. In conclusion this type of gear modification does seem to be effective at reducing cod catches but there can be considerable variation due to diurnal conditions and haul effects such as catch size and catch composition. The one advantage of all of these gear modifications are that they are relatively simple and cannot be circumvented easily by fishermen. To incorporate these modifications it is inevitable that in some cases redesign and retailoring of the original net design are required. In most cases however, the changes required can be made relatively simply and practically.

Some success has been reported with separator panels to sort cod from flatfish although traditional horizontal separator panels with dual codends developed in the 1980s in Scotland do not seem to work effectively. This gear tends to sort cod and flatfish into the same compartment or codend and so without an additional modification i.e. increased codend mesh size or release panel will not sort cod from flatfish. Trials in Newfoundland reported by Hickey *et al.* (1998) with a horizontal panel resulted in cod being split 50:50 between top and bottom codends. Following these experiments the authors concluded that to prevent high losses of plaice catches the height of the separator panel would have to be set at a level at which 50% of cod catch would be retained, which defeated the objective of this trial, to reduce cod catches to very low levels. Thus, it is concluded that the horizontal panel does not seem to be an option if the objective is to sort cod from flatfish although it will sort cod from species such as haddock and whiting very effectively.

Variations of separator panels have also been tested and Danish and Belgian research using an inclined panel has given significant reductions in cod catches. These trials gave reductions in cod catches of over all sizes of 72% and 39% respectively. However, the authors of the reports from these experiments both concede that further work is needed to make these modifications commercially acceptable, given that high losses of commercial flatfish species were also observed in these trials. With the Danish trials the losses of catch, equivalent to 57% of the total catch value were deemed commercially unacceptable. Trials in other fisheries with similar panels, notably in Ireland and Scotland have also shown it possible to divert cod using an inclined panel out through an escape opening with low swimming species such as *nephrops* passing underneath the panel into the codend.

Therefore it is concluded that the use of inclined panels does seem encouraging and may provide a means of reducing cod catch while maintaining catches of marketable flatfish and other groundfish species. However, separator trawls are much more complex than standard nets. The inclusion of the separating panel requires some re-designing of the trawl and the height of the leading edge of the panel above the bottom sheet is critical for species separation (Main and Sangster, 1985). The panel may also need fine-tuning to achieve good consistent separation and the panel also needs to be tailored to each particular trawl design. These are not insurmountable problems but should be noted.

Various designs of rigid grids (Nordmore grids) have been tested in a variety of fisheries specifically to sort cod from flatfish. The results from many of these experiments are encouraging but defining the correct bar spacing, bar orientation (i.e., vertical or horizontal), shape of fish opening, angle of attack and material seems still to be an issue and very much fishery dependent. The trials by Hickey *et al.* (1995) suggested a vertical bar orientation rather than a horizontal bar was more appropriate for sorting cod and flatfish. The best combination they found in their experiments was a bar spacing of 127mm, set at 67º, which gave a reduction in cod catch of 88%, with corresponding reductions in plaice and yellowtail catches of 9–10%. Similarly He (2002) found a horizontal bar grid worked best for sorting roundfish from flatfish and also included a further modification to the grid with the addition of a large opening on the bottom sheet to release monkfish and skate. Michael and Lee (2009) experimented with a horizontal grid to be bets and in their experiments achieved a reduction in cod catch of 73%, with a loss of flounder of 12%. A slightly different approach has been taken in the Faroe Islands, where the use of the grid is mandatory in one particular inshore flatfish fishery. In this system there is a grid with a 40-mm bar spacing and a two-tier codend arrangement with a codend of 180-mm mesh size placed over the escape opening at the top of the grid to retain big cod and species such as monkfish. The idea of this system is to sort fish and then size select them using different codend mesh sizes. A similar system is now being looked at in the Icelandic shrimp fisheries, where a codend of 135mm mesh size has been placed over the escape opening to retain marketable cod, haddock and whiting (Einarsson pers. comm.). This is similar to the concept described by Graham and Fryer (2006) with a grid and a two-tier codend, whereby the target species in this case *Nephrops* passed through the grid and was retained in the bottom codend, while bigger fish were sorted into a top codend.

While the results from the trials with grid are not definitive they do show that grids can achieve the objective of sorting cod from flatfish and based on their widespread use in many other fisheries seem to be an option to be considered for the 3NO fishery. In some of the experiments almost the entire cod catch can be excluded from the catch using grids. However, the grids do need to be tailored to meet the requirements of the fishery and the bar spacing and orientation optimized to meet the management objectives and also respect the economic viability of the fishermen. It should also be noted that while grid technology has improved greatly in the last decade, the size and rigidity of grids may still pose problems under commercial conditions for certain classes of vessels. Many trawlers have only narrow net drums, causing stowage problems if the drum is narrower than the grid. Vessels with power blocks may also find it difficult to haul the grid through the power block.

Square mesh and T90 codends as well as large square mesh panels are designed primarily to size select cod. Composite codends are designed to size select flatfish and cod in one codend taking advantage of the differences in behaviour and body shape. These gear modifications are only real useful in fisheries were the intention is to reduce the catch of undersize or small cod. If the management objective is to reduce cod catch across all size classes then these modifications on their own will not meet this objective. By increasing the mesh size of the panels or codends larger fish can be released but at a certain mesh size this will lead to unacceptable losses of other species. An example of this is the recent work in Denmark reported by Madsen *et al.* (2008). With a 150-mm square mesh panel. Cod catches of all sizes were reduced by 36% with a corresponding loss of plaice > mls of only 2%. When the mesh size of the panel was increased to 300–400 mm, cod catches were reduced by 61–85% but plaice catches were also reduced to 70%. In addition to mesh size position of the panel also is important. For cod, research has indicated that the panels should be positioned as close to the codend or as part of the codend to be effective. For other gadoid species such as haddock and whiting position of the square mesh panel seems less important. It is concluded that square mesh codends and composite codends have been shown to be reasonably effective as size selection devices for cod without reducing catches of flatfish. The composite codends have the added of benefit of being size selective for flatfish species. Large mesh square panels are a simple and cheap alternative and as shown by the experiences with the large mesh Danish windows can be adapted to release cod over a wider size range than simple codends. Further work with these large mesh windows is needed to tailor the mesh size to the fishery and gear to minimize losses of marketable species including flatfish.

Regarding the other gear modifications reviewed by WGFTFB, most of them seem to be effective at reducing cod catches and in the case of the Eliminator trawl and raised footrope trawls can be used to eliminate cod catch entirely across all size classes. However, these gears are only applicable in targeted haddock fisheries as catches of other marketable species are also significantly reduced. The Scottish belly trawls and Orkney trawls are modifications of the Eliminator trawls and have been shown to reduce rather than eliminate cod catches. There is some evidence than they are more effective for smaller cod, although in the case of the Orkney trawls significant reductions in cod catches for fish up to a length of 78 cm was observed. These gears also have the advantage of retaining more groundfish species such as megrim and monkfish so have more potential in mixed fishery situations. It is conclude these gears should be further tested in other fisheries to ascertain whether they are an effective "cod reducing" gear.

As far as the other non-trawl gears examined, at this juncture it would appear there is only limited potential for adoption of these gears as alternatives. The limited trials with Scottish seine gear are inconclusive although suggest it is technically feasible to sort cod from flatfish in this gear but further work is needed to develop acceptable modifications. The work with gillnets is further advanced and through simple modifications reductions in cod bycatch of 50% without significant reductions in flatfish catches have been achieved. Given these gears are perceived as environmentally benign in comparison to towed gears, again further research in this area should be encouraged. Research into using bait as a means of reducing cod bycatch in longline fisheries is encouraging but is only likely to be effective in directed longline fisheries for species such as haddock and possibly halibut. There have been concerted efforts in recent years to develop targeted pot fisheries for cod and flatfish in a number of countries but to date with only limited success, mainly due to low catch rates. This work remains in development phase so could not be recommended as an alternative method currently.

13.5 Conclusions

The *ad hoc* group of WGFTFB has produced this compilation of fishing gear and fish behaviour studies which have attempted to separate:

1) Atlantic cod from flatfish including two conducted in NAFO area 3NO and;

2) Atlantic cod from other species including other commercial flatfish species.

Behavioral reviews have revealed that differences between cod and other species do exist, either in terms of natural separation or in its reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations.

WGFTFB cautions that in the absence of specific details such as gear descriptions, vessel types and management objectives, no single gear modification can be recommended to NAFO at this time. WGFTFB, however, has identified some gear modifications which demonstrate that the separation of cod from other species, including flatfish, is possible. This can be achieved by modifying the front section of the trawl, installing a sorting device such as a rigid grid or separator panel, by using large mesh escape panels positioned above the codend or by modifying the codend itself. These do need, though, to be tailored to the specific requirements of a given fishery and limitations with all of these gears have also been identified and documented. Other modifications such as the "Eliminator" and Raised footrope trawls have been proven to eliminate cod catches almost entirely but are only really suitable for targeted haddock fisheries.

Studies examining separation techniques for non-trawl gears were also identified and briefly reviewed. These include modifications to Scottish seines, gillnets, longlines and pots. Testing of gear modifications to Scottish seine nets is an extension of similar modifications made to trawls. The limited data available is inconclusive but it seems technically feasible to target flatfish with this gear with reduced cod catches.

There has been extensive work with gillnets in recent years and through simple modifications significant reduction in cod catches can be achieved when targeting flatfish species. Gillnets are accepted as selective gears and further research on a commercial basis to establish whether these modifications can yield catches at economically viable levels of other species should be encouraged.

Using bait to sort catches in longline fisheries seems technically feasible but has only really been used to reduce cod catches in targeted haddock longline fisheries. More research is needed to establish whether this can be extended to other fisheries where cod is considered an unwanted bycatch due to stock pressures.

Experiments with fish pots are widespread in many areas and fisheries. Most of this work has concentrated on developing selective fisheries for cod. There are several reports of attempts to develop flatfish pot fisheries but catch rates observed have been at low levels and pot fisheries for fish remain in a developmental phase.

14 Summary of other presentations

14.1 Oral presentations

14.1.1 Investigation of the Paired-Gear Method in Selectivity Studies

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Abstract

We estimated selectivity parameters using simultaneously the paired-gear and covered codend method for two fish species and four different selection systems, for a total of eight study cases. The deviation (Δ) in L50 and SR between these sampling methods observed in a former simulation study was repeated throughout the eight cases in this investigation. When using the paired-gear method, the distribution of the estimated L50 and SR is wider; the distribution of the estimated split parameter has a higher variability than the true split; the estimated mean L50 and SR can be biased; the estimated between-haul variation is different from that estimated by the covered codend. Δ L50 and Δ SR decrease when the number of fish in the codend increases, but they do not necessarily progress towards zero. Δ L50 and Δ SR are positively correlated with the deviation between the split and the true split. We recommend that the methodology used to obtain selectivity estimates using the paired-gear method be reviewed.

Discussion

The question was raised if the results were more similar when the split parameter was close to 0.5. It was explained by the author that this was not the case as the model was based on the difference between the model estimates of the split against the calculated split. A further question was asked whether the results referred to the combined selectivity of grid and codend for the covered codend experiment. The author explained that the cover used was 25 m long so covered both the grid and the codend and therefore it was combined selectivity that was measured. It was further pointed out that it would have been very difficult to try to measure the selectivity of the grid and codend separately.

It was further asked as to whether it would be possible to suggest limits to paired gear methodology as it was for subsampling in ICES selectivity manual. It was stressed that care must be paid when comparing the results between the methods.

Concern was raised that this was a complicated study and the results were based on a limited number of observations. The author concluded that a more comprehensive study is required to validate the results more fully.

14.1.2 Estimation of Distribution Density of Snow Crab, *Chionoecetes opilio* and Net Efficiency of Survey Trawl for Snow Crab Using A Deep-Sea Underwater Video Monitoring System on A Towed Sledge

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Abstract

Experiments were conducted to evaluate the distribution density of snow crab, *Chionoecetes opilio* and the net efficiency of a survey trawl for snow crab, using a deep-sea underwater video monitoring system (DUVMS) on a towing sledge and bottom survey trawl gear.

Field experiments were carried out in the Uljin waters, east coast of Korea ranging from 110 m to 350 m in depth in 2007 and 2008 with the NFRDI R/V Exploration 5 (262 G/T, 39.4m length).

Distribution density of snow crab (A, number/1000m^2) for each observation was estimated with the number of crab in the swept area collected by DUVMS.

Trawling was carried out by following the trace of the towing sledge and the catch density of trawl gear for snow crab(B, number/1000m^2) was obtained from the number of crab caught by swept area net(wing end spread × towed length).

Net efficiency (the proportion of the number of captured crabs to crabs in the swept area calculated as the towing distance multiplied by the trawl net width between the wing tips) was estimated by using catch density of the trawl gear (B) per distribution density (A) of crab.

The distribution density of crab was shown to increase significantly according to the depth. Net efficiency of survey trawl (B/A) for snow crab was observed to be ranged between 0.20 and 0.48 and its mean was estimated to be 0.34.

Discussion

The question was raised whether it was easy to recognize and count the species. The author explained that image analysis was time consuming and quite difficult. In this respect he asked the expert group whether any members had information on techniques or software that would help this process. He did indicate that his institute was trying to develop software to automatically recognize and count the crabs. The chair indicated that it would be useful to contact the chair of a recent ICES workshop on counting *Nephrops* burrows.

14.1.3 How Three Different Hauling Techniques Influence Retention Proportions Of Fish In The Norwegian Mechanized Longline Fisheries

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Abstract

During a 10-day period in December 2008 the Norwegian College of Fishery Science, Tromsø, conducted a cruise with three offshore longline vessels. Each vessel carry different hauling technologies; MV "Geir" hauled the line through a moon pool in the

centre of the hull, MV "Loran" hauled the line trough a hatch in the waterline (later referred to as ALH) and MV "Vonar" used traditional gaffing with a modified rail roller. The intention of the cruise was to estimate the quantity of fish retained with each system. The three vessels fished side by side throughout the test-period and each vessel carried a research team onboard. The results showed a significant difference in numbers of cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) lost during hauling between the vessels; with the traditional method and gaffing the loss was 2.49 % and 3.03 %, with the ALH method the figures were 1.35 % and 1.55 % and with the moonpool system losses were 0.4 % and 0.82 % for cod and haddock, respectively.

Discussion

The question was asked whether fish are lost using the moon pool system due to abrasion of fish being hauled on the opening of the moon pool. The author replied that there was some evidence from cameras mounted at the entrance of the moon pool that this was likely.

The question was asked whether it was likely that existing longline vessels would fit the system. The author explained that it was unlikely that existing vessels would do so given the cost implications. However, he did indicate that owners considering or in the process of building new longline vessels were strongly considering fitting this new hauling system.

14.1.4 Fleet spatial dynamics in Portuguese coastal trawlers

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Abstract

The understanding of spatial and temporal dynamics of the fishing activity is recognized as having major importance to the formulation of conservation and management policies. Particularly in multispecies fisheries, fleet segmentation is a fundamental step to understand fishing patterns, allowing estimating species-directed effort; to implement by-catch and discards mitigation policies; and to understand fishermen decisions on what and where to fish.

Landing profiles of the Portuguese coastal trawl fleet (about 100 trawlers) and associated fleet components (FCs) are defined based on landings per vessel data for the period of 2002–2004. In addition to the two main FC, comprising the 'fish' and crustacean trawlers, a third group of vessels mostly targeting cephalopods was identified. Seasonal changes between Octopus and *Sepia* were observed within a small group of old units, while for a larger group of modern trawlers, a well-marked seasonal pattern between the catches of cephalopods and horse mackerel was found.

Fishermen individual decision to return to the fishing ground of the previous trip was modelled for a number of fishing units engaged in the Portuguese coastal trawl fishery, using econometric discrete choice models. For this purpose, geo-referenced information of a total of 1356 fishing trips was extracted from Portuguese vessel monitoring system data and combined with commercial landings using GeoCrust 2.0 software. The landed weight of target species was found to heavily influence the fleet

spatial distribution. The distance to the fishing grounds, an indirect indicator of overall fuel consumption, was also found to be an important predictive factor.

14.2 Poster presentations

14.2.1 Relevance of dual selection in grid based selectivity studies

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Abstract

Traditionally, the selectivity of grid based systems has been measured as a joint grid + codend selection system. However, questions like "what is the relevance of the mesh size in a codend placed subsequent to a grid?" have enhanced the necessity of separating the role of each of the devices in the overall selectivity of the system. Two conditions need to be fulfilled so that a fish can escape through a grid: a) the fish needs to come in contact with the grid and b) the fish should be able to physically pass through the grid. In this study, we introduce the variable "grid contact" (C*grid*), which determines what percentage of fish comes actually in contact with the grid, in a grid based selectivity study. No work has evaluated this so far and previous studies have assumed a grid contact equal to 100%.

The data collection for the present investigation was carried out with a setup where a cover over the grid and a cover over the codend collected the fish escaping from each of the devices. In this study, a 55 mm Sort-V sorting grid device was alternatively combined with a 135 mm and 140 mm diamond mesh codend. All cod (*Gadus morhua* L.) and haddock (*Melanogrammus aeglefinus* L.) above 30 cm were measured in the three compartments of the gear: grid cover (GC), codend (C) and codend cover (CC). The data were analysed using the computer software SELNET.

Haddock is a much more active fish than cod inside the trawl and tends to seek for escapement on top. It is therefore not surprising that C*grid* for haddock is higher than that of cod.

With few exceptions, grid selectivity studies have evaluated the overall selectivity of a grid + codend setup incorporating the fish escaping through the grid and the codend as a single compartment. Although data collected in this way can be analysed as dual selection data, the present study reveals differences in the same datasets depending on whether the fish escaping through the grid and the codend are incorporated in the analyses separated or joined.

The necessity of collecting the data in separate compartments to avoid deviance from the correct estimates is therefore demonstrated. For this reason, dual selection analysis results obtained with joined GC and CC should be interpreted carefully.

14.2.2 Can codend selectivity of *Nephrops* be explained by morphology?

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Abstract

Selectivity of *Nephrops* in trawl codends is in general poor with resulting high discard rates and / or loss of legal sized catch. In the present study, the FISHSELECT methodology has been used to attain a profound understanding of the selection process of the species in order to identify means to improve the selectivity. It was found the size selection of *Nephrops* in trawl codends can be explained by combining contributions resulting contacts with the meshes for three different modes of orientations of the *Nephrops.*

14.2.3 New approaches to selectivity studies in the Barents Sea

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Abstract

We collected data for four important species in the Barents Sea demersal trawl fishery by means of the FISHSELECT methodology and tools (Herrmann *et al.*, 2009). The cruise was carried out on board R/V Jan Mayen from 24 November to 4 December 2008. FISHSELECT is a simulation-based method to investigate size selectivity in trawls. It is based on measurements of fish morphology and fall-through experiments. The collected data are analyzed using the FISHSELECT software and the results obtained are applied to investigate trawl selectivity through build-in simulation facilities.

We used 191 different mesh templates to mimic meshes and escapement devices of different sizes and shapes. Data for 110 haddock (*Melanogrammus aeglefinus*), 103 cod (*Gadus morhua*), 100 Greenland halibut (*Reinhardtius hippoglossoides*) and 100 red fish (*Sebastes marinus*) were collected making a total of 78883 fall-through measurements.

For each species and individual, we measured the cross section contour at different positions along the body using a FISHSELECT morphometer. The footprint left in the morphometer was then scanned and saved into a computer as an image. The image analysis tools in the FISHSELECT software automatically extract and digitize the cross section contour for later build-in parametrical description. We collected a total of 1139 scanned images during this experiment.

So far, the data has been collected and the analysis is ongoing. The first step is to describe the cross section shapes of the different species by some of the build in shape descriptions in FISHSELECT. FISHSELECT contains more than 100 different flexible parametric shapes.

14.2.4 Modelling escapement during the fishing process as a dual sequence – Introducing SELNET

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Abstract

We compare modelling of selectivity data by two different models. The data modelled were collected in experimental fishing trials using a multiSampler or a dual-sampler. The purpose was to separate the fish escaping during towing at the seabed from the fish escaping at a later stage of the fishing process (haul-back and at surface). The first models led to a description which is similar to what has previously been used to model and analyze this type of selectivity data (Madsen *et al.*, 2008; Grimaldo *et al.*, 2009). The second model is more flexible and contains the first as a special case. It adds another parameter that could actually be linked to fish behaviour, which is of special interest in this kind of selectivity experiments. We show results for a number of different species and demonstrate that the new model is better at describing the data in some of the cases. In addition, the values obtained for the behavioural linked parameter make sense when comparing the different species. For simplicity, we only show preliminary results for pooled hauls. The second model has a similar structure to the one applied by Zuur *et al.* (2001) to model escapement through an escapement panel and a codend separately.

A new flexible software tool named SELNET has been developed to analyse these and other selectivity data for towed fishing gears. SELNET can handle collection and analysis of data for a number of different experimental designs such as covered codend, paired gear, catch comparison and catch data. Besides the standard curves Logit, Probit, log-log and Richard, SELNET contains a number of other curves (including the models we use in this study), which are derived from combining these.

14.2.5 Development of a long range pinger detector for acoustic deterrents used in the set-net fishery

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Abstract

Council Regulation (EC) no 812/2004 requires the mandatory use of acoustic deterrent devices on bottom set-nets and entangling nets. No guidance is provided how to control the correct function and usage.

A newly developed tool for inspection (ETEC, Denmark) was tested in several continuously improved prototypes and under different working conditions. The final version is able to identify pingers at a range of up to 400 m for both digital and analogue signals with the aid of headphones. An optical identification by incorporated LED- indicators for the frequencies used is possible at a range of 50 m. Long range detection by headphones is dependent on sea state and background noise emitters (auxiliary ship engines). Automatic gain control ensures optimum signal strength.

The device is currently in use with Danish (Danish Directorate of Fisheries) and German fishery authorities (Federal Agency for Agriculture and Food).

15 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**.

15.1 Belgium

Institute for Agricultural and Fisheries Research

National project: "An integrated impact assessment of trammel net and beam trawl fisheries" (WAKO-II) [Funded by Belgian Science Policy (www.belspo.be), SSD nr. 4 Targeted actions "North Sea"]

The beam trawl fishery has been questioned from both economic and ecological perspectives. One of the alternative gears is the trammel net, a passive fishing method with a higher economic potential, as it is much less dependent on fuel. However, its environmental impact has only been quantified on a limited basis for the Belgian Part of the North Sea (BPNS). The effects of beam trawl and trammel net fisheries are partially being reviewed within the WAKO-I project and knowledge gaps have been identified. WAKO-II will address these gaps and aims at an integrated assessment of the effects of beam trawl and trammel net fisheries for five structural ecosystem components: endofaunal and epifaunal invertebrates, fish, seabirds and marine mammals at the BPNS.

The integration of spatial full cover distribution maps of key species, sensitivity analyses and the best available information on fishing effort will enable us to spatially map the impact of the two most important Belgian fisheries and will provide a baseline for the development of policies, leading to an appropriate environmental management and a sustainable coastal fisheries management for both beam trawl and trammel net fisheries.

Contact: Jochen Depestele (Jochen.depestele@ilvo.vlaanderen.be)

EU-project: "Development of fishing Gears with Reduced Effects on the Environment" (DEGREE) (Contract SSP8-CT-2004-022576)

This projects aims at the investigation of ways of reducing the environmental impact of beam trawl fisheries (reduction of discards of non-commercial fish and invertebrate species and undersized commercial fish species) and the possible solutions to technical drawbacks for voluntary implementation in the Belgian beam trawl fleet.

Contact: Jochen Depestele (Jochen.depestele@ilvo.vlaanderen.be)

FIOV-project: "Alternative beam trawl"

This projects aims at the investigation of reducing the environmental impact of beam trawl fisheries (reduction of discards of non-commercial fish and invertebrate species and undersized commercial fish species) and reduction of fuel consumption. Several technical modifications are combined in the beam trawl such as a benthos release panel, more selective codends, large meshes in the top panel, lighter chains and roller gear. A voluntary experimental phase and a voluntary uptake by the industry are envisaged. Already an industry working group has been established with trials on board commercial vessels.

Contact: Hans Polet (hans.polet@ilvo.vlaanderen.be)

National Project "Trammel- and gill net fishing, traps and pots" (project° VIS/07/B/01/DIV)

This project aims at the testing of various static gear, traps and pots in order to determine the possibilities of multi-purpose, alternative fishing methods. The fishermen need to be able to diversify throughout the year to target various species at optimum times of the year. Protecting spawning periods, reduction of bycatch and selectivity are important. By means of a broad range of various static gears, fisherman will be able to be flexible for the whole year and switch fisheries depending on market demand. By means of exploring these fishing methods, we can offer an alternative for beam trawl fishing and attract new investors, which is essential for the basis of a whole new versatile and profitable fishing fleet. Additional funding for five years has been requested to extend this project and have sought other external partners regarding further development.

Contact: Dirk Verhaeghe (dirk.verhaeghe@ilvo.vlaanderen.be).

National Project: "The impact of fishing gear on fish quality" (traditional versus alternative beam trawl) – (project° VIS/07/B/02/DIV)

This project aims to verify if sole and whiting caught with an alternative beam trawl (equipped with a T-90 net or benthos release panel) are of a better quality than those caught with a conventional beam trawl. The basis of comparing will be the "Quality Index method", PH- and Total volatile base analysis and the "Injury Index Method" under development.

There is a growing opposition against beam trawl fishing so every bit of upgrading and improvement of this fishing method needs to be verified before switching over to alternative methods. The consumer market is demanding improved fish quality linked to sustainable fisheries where upgrading efforts have been already carried out. Additional funding for five years has been requested to extend this project and have sought other external partners regarding further development.

Contact: Dirk Verhaeghe (dirk.verhaeghe@ilvo.vlaanderen.be).

National Project: "Development and demonstration of a species-selective electro-shrimp trawl for the brown shrimp fishery with the focus on the reduction of discards and the environmental impact" ["PULSKOR" (project number VIS/05JE/01/DIV)]

The discarding practices associated with the brown shrimp fishery have been regarded as a problem for many years. The poor selectivity of the small mesh nets used produces very high amounts of unwanted by-catch. Consequently the implementation of adequate selectivity enhancing measures should result in both ecological and commercial improvements.

This national project was set up to investigate the potential of electric pulses as a means to develop a species-selective electro-shrimp trawl. This new type of fishing gear focuses on the reduction of unwanted by-catch, the reduction/elimination of bottom contact and the improvement of catch-quality.

Contact: Bart Verschueren (bart.verschueren@ilvo.vlaanderen.be)

National Project: Evaluation of climate change impacts and adaptation responses for marine activities (CLIMAR)

The North Sea Ecosystem is characterized by high productivity and highly diversified habitats but also by an intensive use. As a consequence the vulnerability of the ecological, social and economic community formed by the North Sea is high (in terms of risk on damage) for climate change. This calls for a sustainable approach when addressing climate change issues in the North Sea.

Research and modelling will be carried out to differentiate the primary impacts of climate change from the natural evolution at the North Sea scale. These primary impacts include sea level rise, increased storminess, possible increased rainfall, erosion, temperature changes, salinity, etc. Then secondary impacts of climate change both on the ecological system of the North Sea as well as on social-economic activities will be assessed. Two extensive case-studies (coastal flooding, fisheries sector) have high extrapolation potential towards the global North Sea environment. Adaptive measures will be formulated both for the ecosystem as well as for the other marine activities. Based on in-depth application for the two above mentioned case-studies, an evaluation tool will be developed to assess the impact of these measures according to the principles of sustainable development. Using parallel integrated assessment and policy and legal evaluation, recommendations will be formulated towards North Sea future policy. ILVO-Fisheries will be responsible for the development of the impacts of climate changes on the fisheries sector, the development/evaluation/extrapolation of different scenarios and adaptation measures for the Belgian fleet, and the formulation of a series of recommendations.

Contact: Els Vanderperren (els.vanderperren@ilvo.vlaanderen.be)

15.2 Canada

Fisheries and Marine Institute of Memorial University of Newfoundland

Low Profile Trawl for Northern Shrimp

Earlier results using a multi-level trawl revealed strong variation in the vertical density distribution of shrimp in the mouth of conventional trawls used in Newfoundland and Labrador waters. The results led to the subsequent design and flume tank testing of new low-profile wide-opening trawl designs for both the inshore and offshore fleets. A full-scale prototype has been constructed for the inshore region and was tested last summer. Further refinements are currently being planned.

Contact: Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Cod Potting

A unique marketing experiment was conducted in the fall of 2008. Cod pots and handlines were used to harvest 3200 lbs of Atlantic cod in the community of Fogo in Newfoundland & Labrador. A specialty restaurant (Nicole's Café) agreed to purchase the single enterprise's Atlantic cod at top dollar prices and market the product as "fresh pot caught cod" on their menu. The project was a success and additional niche markets are being developed for 2009 with ten (n=10) harvesters expected to sell their Atlantic cod to these markets. In 2008 the harvester collected an extra $900.00 over and above what he would have received using the traditional harvesting method.

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. Further expansion is currently underway, with an additional 31 fishing enterprises included for the upcoming 2009 season. This brings the total participation to 70 enterprises in 41 communities. 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 (Paul.Winger@mi.mun.ca).

Fuel Efficient Shrimp Trawl

Flume tank modelling is currently underway with a local gear manufacturer to reduce towing resistance of the typical inshore Newfoundland shrimp trawl. Models at the 1:4, 1:8 and 1:40 are currently being built and evaluated for various characteristics and parameters.

Contact George Legge (George.Legge@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 is currently underway to evaluate various natural fibres/ twines (cotton, hemp, jute, and sisal) for their breaking strength over time under cold Newfoundland conditions. The project will identify a “preferred twine” and commercial trials with harvesters are expected in the 2010 fishery. The results might ultimately be used to introduce a technical measure whereby the material is sewn into 3–5 mesh bars at the bottom of the trap, as is currently practiced elsewhere in Atlantic Canada.

Contact George Legge (George.Legge@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 Quebec Region

Unaccounted fishing mortality 101

In an attempt to better understand the fish catching process, a fate monitoring program was started in the summer of 2008. Through the staff of the Quebec based observer programme, the fate of fish were assessed as they are taken out of the water into three categories; alive, dead or decomposed. Length measurements of the fish in these three categories were also collected. This was done on directed and by-catch of cod, Greenland halibut, Atlantic halibut in gillnets, longlines and shrimp trawls. Of course, soak time is a key metric that influences the amount of dead and decomposed fish. Ultimately, the amount of unaccounted fishing mortality will be evaluated for assessment purposes.

Preliminary results from the 2008 Greenland halibut gillnet fishery indicated that 50% of soak time was three days and some soak times could even reach 6 to 7 days. The amount of decomposed and dead fish is comparable to the amount of live fish. Decomposed fish are more prevalent when longer soak times are observed.

Contact: Alain Fréchet (Alain.Frechet@dfo-mpo.gc.ca).

Fisheries and Oceans Canada Newfoundland Region

Neutrally Buoyant Rope

This ongoing experiment aims to determine if the use of neutrally buoyant rope reduces entanglements of marine animals (such as leather back turtle) in the 3Ps Snow Crab and Whelk fishery. We have distributed the rope to 5 fishers to initially assess the practicality of using Hydrophone rope in the Snow Crab and Whelk fishery during 2009 season. At the end of the season, entanglement statistics will be compared to 5 fishers using traditional rope. We hope to reduce the entanglements of marine animals in commercial fixed fishing gear while maintaining the fishing effectiveness and handling characteristics of the traditional fishing gear. The information collected will be used by fixed gear fishers and fishery managers to improve management plans to reduce the entanglement of marine animals in the region.

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

Halieutec École des pêches et de l'aquaculture 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 will be conducted this summer in Québec.

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. Based on the new developments in this field, a new gear adapted to our environment will be tested. Sea trials are scheduled this summer.

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

Energy efficiency of fishing boat stabilization

Performances of technologies in fishing boat stabilization 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).

15.3 Faroe Islands

Faroe Marine Research Institute, P. O. Box 3051, FO-110 Tórshavn, Faroe Islands

Contact: Kristian Zachariassen (krizac@hav.fo) and Bjarti Thomsen (bjartit@hav.fo)

Effect of fishery on coral areas

Coral reefs in the Faroese area were mapped some years ago using information from interviews with fishermen. In recent years further details have been obtained using underwater video observations. This project ended in 2008 and a detailed report will be available in 2009. The information will be used in the discussion with stakeholders on preserving coral reefs. Three coral areas are already closed for trawl fishery to prevent damage of corals by trawls.

Groundgear development

Experiments to reduce the impact on the bottom from trawl groundgears have been carried out in recent years. Underwater video observations have been used to monitor gear on the bottom. This work is now integrated in the EU project 'DEGREE'. Experiments with a combined plate gear with rolling bobbins have been carried out on Norwegian research and commercial vessels in 2007. The final concept was tested on the final DEGREE cruise onboard F/V G O Sars in November 2008.

Development of static gear

A project to develop fish pots with increased catch efficiency for traditional fish species has been carried out in the Faroe Islands since late 2005. The project has generated a substantial amount of underwater video observation of fish behaviour around fish pots, especially of Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). On several occasions fish (cod) have been observed to be attracted to the sudden movement of other fish. It is not clear whether these attractions are a result of purely visual stimuli or whether sound and mechanoreceptor stimuli are involved. To investigate this in more detail a system to control an 'electronic' vibrating fish has been developed and the first trials began in May 2009. The work on fish behaviour around fish pots will be continued for the next two years to clarify whether means can be found to attract and agitate fish to readily enter fish pots and thereby increase catching efficiency. Also underwater video observation systems have been further developed to include smaller and better instruments.

Pelagic trawl research

The research project to optimise pelagic trawls reported in 2008 has been continuing. Collection bags have been used to quantify the escape of blue whiting and herring from the aft parts of a pelagic survey trawl. This research showed that the escape from these parts of the trawl can be substantial at times. The cause of this escape is not well known. Reductions in water flow or changes in geometry of the trawl in the immediate front of the codend might be causes and these will be further investigated.

Trials with Doppler measurement equipment of water flow have been done inside the trawl in 2008. These measurements were not conclusive and again will be continued.

Effect of coloured "flags" on gillnets for monkfish

In 2008 experiments were made to test whether coloured "flags" on gillnets affected the fishing efficiency for monkfish. A fleet of 200 gillnets with 5 different colours of "flag" were tested. The fleet was tested 23 times and the fishing time was approximately 3 days for each test at depths around 200 m. The experiments will continue in 2009.

Atlantic cod tagging project

The tagging experiment of Atlantic cod initiated in 1997 has been continued. Now, more than 28 000 cod have been tagged on various locations on the Faroe Plateau. More than 8 300 cod have been recaptured, and analyses of stomach content are available for more than 1 900 of these fish. Analysis of this material provides valuable understanding of the migration patterns and feeding behaviour of cod on the Faroe plateau.

15.4 France

IFREMER

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Energy savings and lower impact on the seabed

Semi-personalized diagnosis of Breton trawlers

The second stage of this study dedicated to the semi-personalized diagnosis of Breton trawlers, managed in partnership with Brittany regional fisheries committee, was carried out in cooperation with several manufacturers Le Drezen, Morgère, IxtTrawl, and Docks de Keroman. The results achieved were presented to the industry as well as to the Economic and Social Council of Brittany. The upshot of the study is 1) a potential saving of 5 to 17% of the global energy consumption of a trawler, depending on its size, and 2) a depreciation period ranging between 3 to 40 months for a new complete fishing gear, though most of the time it is achieved in less than 1 year. The theoretical economic outcomes achieved with the numerical simulation tool (DynamiT) were confirmed by measurements at sea onboard 3 commercial vessels.

OPTIPÊCHE

As part of this project conducted with the support of the Brittany Region, a novel type of doors was developed in cooperation with Morgère Company. It enables a substantial energy saving (around 25% versus standard doors, i.e. 5% of the total consumption of a trawler — the doors accounting for some 30% of the fishing gear which itself stands for 2/3 of the total fuel consumption) along with a reduced impact on the seabed (backed up by video footage). The fishermen have received this new type of door positively and several boats are already using them.

DEGREE (EU)

Still in partnership with Morgère Company, this European project also enabled to develop a prototype of novel door exerting a reduced impact on the seabed.

ESIF (EU)

The European project ESIF (Energy Savings in Fisheries) was completed at the beginning of 2009. Its aim was to analyse the fuel expenditures of various types of fishing boats: costs linked to transit, fishing operations, to the boat, etc. Novel analysis tools were developed so as to define the investments that enable operators reduce energy consumption according to the way the boat is fished. Several methods aiming to reduce energy dependence have also been implemented along with an economic approach. The various analysis tools can estimate with good precision the distribution of energy consumption, which is 1/3 for the boat and 2/3 for the fishing gear usually used as an estimate.

IFREMER' contribution focused on the economic analysis of energy consumption for each type of boat and its activity, and on the numerical simulation of representative fishing gears (DynamiT simulation tool).

French Fisheries Directorate call for tender

Issued at a national level by the French Fisheries Directorate, a call for tender enabled the initiation of several projects on various topics dedicated to energy savings in fisheries: ITSASOA (colza oil), HYDROPÊCHE (net hydrodynamics and gear optimization), COCHISE (novel trawler), OPTIPERF (vessel hydrodynamics), and MACH (Stirling engine).

Project Hydropêche

Three doctoral thesis, supported by the Fisheries Directorate (on the theme of fisheries energy), started at the beginning of 2009. All three will contribute to improve our knowledge of the flow in nets so as to improve their design. The potential applications concern many projects dedicated to fisheries technology. One of the students is developing a method of automatic optimisation of the shape of towed devices so as to reduce their hydrodynamic drag. Another student is developing a novel method to simulate the flow around the net in motion in the water. The third thesis is experimental and will enable to provide a better analysis of large eddies in the fishing gears All three are complimentary of each other.

Alternative fishing gears

Itis-Squal: Fish pots

Labelled by the Brittany sea pole of competitiveness, the project started on 1st May 2007 (duration 3 years). It has the main objective of the development of fish pot and *Nephrops* trap fishing techniques, and on improving the quality of trawl catches. In 2008, a survey aiming to test the feasibility and observation systems was carried out in the Ile de Houat area, in October 2008

The objective was to deploy the observation devices, both inside and outside a prototype floating pot developed by IFREMER Institute and the net manufacturer Le Drezen. The tests were also meant to validate the hydrodynamic behaviour of floating pots as observed in the Lorient flume tank.

A video system developed for trawl control and observation (VECOC), was deployed to observe the various fish pots tested. The tests completed enabled specifications of the technical developments necessary to define the type of pots, procedure, measurement and observation devices that will be needed for the future tests, including a survey that will be conducted in June 2009 in the Parc Marin d'Iroise, onboard the *Thalia,* with the support of the Parc Marin. 5 types of fish pots will be tested at different heights above the bottom. The pots will be cylindrical or parallel pipedic, with 2 chambers, either vertical or horizontal.

Orcasav

Agreed by both the Pôle Mer Bretagne and Qualitropic (La Réunion Island), this project was launched late 2008. It owes its acronym to its themes: "Pêche aux CASiers pour lutter contre la depredation par les Orques et la mortalité Aviaire" (fish pot fishing to fight against the damage caused by killer whales and seabird mortality). The objective is to develop a novel fishing method for toothfish in the area of the Kerguelen and Crozet Islands. The project will involve several fishing companies, a fishing gear manufacturer, and institutional organizations.

Itis-Squal: *Nephrops* traps

In 2008, several tests on *Nephrops* traps were conducted onboard commercial boats, in the Bay of Biscay, at La Cotinière and Lorient. These were a follow-up to initial experiments conducted in 2007 in the non-trawled area of Capbreton trench. Additional testing has also been completed by the pot-trawler *Lambada* registered in La Cotinière. Fifty traps, supplied by IFREMER were tested along with10 prototype folding traps manufactured by Le Drezen.

The traps were deployed in 50 m depth around the area Chardonière, within the limits of the trawled areas, and over the period June to September 2008. Once the technique had been optimised (kind of bait, way of positioning the pots), an average catch rate of 91 g per trap/per haul was achieved. No *Nephrops* below the landing size were caught and the average size of *Nephrops* caught was around 110 g. By way of comparison, the average weight of *Nephrops* landed in the Bay of Biscay by trawlers is 25g.

Though no captures of *Nephrops* have been logged in the preliminary tests completed with the foldable traps, the fishermen still show interest in this device and have suggested several improvements.

Two test surveys have also been completed at the end of November 2008, in Lorient, on the *Ikaria*, a boat already experienced in *Nephrops* trap fishing. Two series of traps have been observed with 125 and 155 traps immersed respectively. 50 Scottish type traps of a new non-foldable concept were also lent by IFREMER to the *Ikaria*. No significant difference has been observed between the various types of traps. Over the two series of tests, the *Nephrops* average catch rates were respectively 96 and 115 g. The average weight of *Nephrops* caught was around 60g.

Selectivity

Selecmer

The continuation of the project, which started early 2008, has made it possible to validate the concept of a flexible grid on the basis of the developments achieved as part of the former project Sauplimor though flume tank testing in Boulogne-sur-mer. The aim is to reduce significantly whiting discards in the trawl fisheries registered in Boulogne sur Mer and Etaples and operating south of the North Sea and in the eastern area of the Channel.

The flume tank tests gave rise to many exchanges with the industry concerned as represented by the Regional Fisheries Committee. Further to the flume tank tests, some prototypes were built by ResiConcept Company on the basis of the characteristics provided by IFREMER. A feasibility and observation study initially planned for late 2008 was conducted at the end of February 2009. The grid showed perfect ergonomics and high quality video pictures were achieved, which both enabled the preparation of a second survey concentrating on measuring the selectivity of the grid. These tests were carried out at the end of February 2009. Promising results were obtained on small whiting (less than 20 cm length), though additional tests are needed with a wider bar spacing grid and also with the inclusion of a square mesh panel below the grid. These tests will enable fishermen to propose reliable technical solutions to the national authorities and the EU to reduce whiting discarding.

New tests will also be carried out in 2009 on cod selectivity, in partnership with the French National and Regional Fisheries Committees. Large mesh trawl and rope trawls will be tested as well as one combined grid designed for reducing discarding of both whiting and cod.

Marifish: Discards meeting, Lyon, France, 28–29 October 2008

The partners involved in WP7 of this project (United Kingdom, Norway, Germany, Spain, Greece, Sweden, Denmark, Poland, Ireland, Belgium and France) have presented their respective studies aimed at reducing discards in *Nephrops* fisheries in ICES area VII. The objective is to develop or improve existing selectivity devices; to demonstrate these devices to industry; and to collaborate with the EU to simplify existing TCM regulations. One team of technologists agreed to concentrate their efforts to work on the rigging of T90 mesh.

Security

SOS stabilité: Security at sea

The kick-off meeting of this project was held on 9 February 2009. The project was approved by the Pôle mer Bretagne and the Pôle Provence-Alpes-Côte d'Azur (PACA), and supported by the FUI (Direction générale des enterprises), Brittany and PACA regions, and the general Council of Morbihan region. The project involves several scientific and technical organizations.

Commercial fisheries are recognised as one of the most dangerous activities in Europe and globally. The main goals of the project, using the dynamic stability of 12–24 m fishing boats as a basis, are as follows:

1) To develop and implement ship-borne devices, likely to improve safety conditions onboard the ships.
2) To design novel ships, fishing gears, and the interfaces between them.
3) To train the crews via tools produced by the project.

The intermediate steps necessary to achieve these objectives will be:

- Better understanding of the phenomenon linked to the problems of dynamic stability of small ships;
- The adaptation or implementation of numerical models enabling a thorough investigation of these phenomena such as design, operation and regulations;
- To provide procedures towards the analysis of accidents.

Cooperation with Quebec in the fisheries sector

Further to meetings hosted in Québec, in 2007 and 2008, between industrialists, organizations and research centres working in the Quebecker marine field, and two French organizations, Pôle mer Bretagne and Pôle mer Provence-Alpes-Côte d'Azur, seven topics of possible cooperation were identified in terms of know-how, technological transfer, research and development in the field of fisheries. The discussions were conducted in IFREMER Lorient, in October 2008, and as a result one of these projects (training and exchange of know-how – DynamiT software) has begun, and also enabled to advance discussions on the other projects within a sustainable development framework, involving firms and research and development centres. A group was created to exchange on the subject of sustainable fisheries. The most promising projects will look at the selectivity of shrimp fisheries in Guyana and Saint-Laurent, along with the possibility of integrating DynamiT software into a fisheries simulator. Several visits were organized to fisheries facilities in Lorient and Le Guilvinec, local fisheries committees, a fisheries training school in Lorient, and to some industrialists (Morgère and Le Drezen). The delegation also visited IFREMER Brest facilities.

15.5 Germany

Institute of Baltic Sea Fishery Alter Hafen Süd 2, 18069 Rostock

(http://www.vti.bund.de/en/institutes/osf/)

The group working on environmental effects of fishing gear and fishing technology is part of the Institute of Baltic Sea Fishery, Rostock. The institute has appointed Dr. D. Stepputtis as the new head of this section in April 2009.

Contact scientists of this group: Daniel Stepputtis, Harald Wienbeck and Bernd Mieske

Selectivity of cod trawls in the Baltic

Within the frame of the ongoing cooperation between Poland and Germany 46 sea trials with a standard ground trawl and different codends were carried out in March/April 2008 onboard FRV "Solea". Cod selectivity parameters of three different codends were evaluated and compared with the Bacoma codend.

No.	Codend type	Mesh opening (mm)	Mean catch cod (kg/h)	L 50 (cm)	Selectivity range (cm)	Selection factor (L50/MO)
1	BACOMA	112.4	152.8	38.7	5.5	3.5
2	T90 PA D5	112.9	132.5	39.1	4.8	3.5
3	T90 PE D5	109.0	262.2	37.8	4.5	3.5
4	T90 PE S5	112.9	177.2	39.7	5.5	3.5

All tested codends had a twine thickness of 5 mm. The corresponding selectivity parameters showed very small differences between all codends: differences were 1.9 cm for the mean L_{50} and 1.0 cm for the mean selection range. The differences in the selective properties between the T90 codends with varying stiffness in the net yarn were, surprisingly, not as high as expected. The mean difference in L50 between the PA and PE T90 codends was 1.3 cm. Moreover, L50 showed little difference with respect to total catch per haul.

A second trial was carried out in September/October 2008 onboard FRV "Solea". Cod selectivity parameters were determined for four different codends made from Dyneema net material in a T0 (rhombic meshes) and T90 (turned meshes) version using single yarn and double yarn with a twine thickness of 2.5 mm. The Dyneema codends were compared with a T90 PE (Euroline, core twine) codend made from single yarn with 5 mm twine thickness.

No.	Codend type	Mesh opening (mm)	Mean catch cod (kg/h)	L 50 (cm)	Selectivity range (cm)	Selection factor (L50/MO)
1	T0 double Dyneema	109.6	128.9	37.8	8.5	3.5
2	T0 single Dyneema	108.5	77.6	39.2	6.8	3.5
3	T90 double Dyneema	109.4	48.4	43.1	4.9	3.9
4	T90 single Dyneema	107.9	63.4	44.1	4.6	3.9
5	T90 single PE Euroline	112.9	141.0	42.3	4.6	3.8

The selectivity parameters for Dyneema T90 codends showed considerably higher L50 and selection factors than the T0 versions and the T90 PE codend. These results demonstrate improved cod selectivity even for the tested T0 codends, which are currently banned by the EU-regulation for the Baltic Sea. In comparison with T0, the T90 codends (single yarn) demonstrate a high reduction from 26% to 1 % in the bycatch rate of undersized cod and higher release rates of marketable cod from 24 to 61% using the mandatory mesh size of 110 mm. Cod above mls (38 cm) makes up less than 10% of the catch. To obtain selectivity results comparable with the legal Bacoma codend, the mesh opening has to be reduced to <= 105mm in the cod fishery when using a T90 Dyneema codend. It was concluded that it was necessary to perform a study on the long term durability of Dyneema net material for codends in ground trawls.

Contact: Harald Wienbeck (harald.wienbeck@vti.bund.de)

Catch efficiency of experimental trawls in the Baltic

Experiments with a topless trawl (reduced top sheet) were conducted to design a flounder trawl, which minimized the catch of cod. Comparisons between stern trawlers and side trawlers revealed differences in selectivity, but generally, a reduction in cod catch around 85% was achieved with the topless trawl. However, this was also accompanied with a loss of the target species (flounder) when fishing with the stern trawler, while the opposite was true for the side trawler.

Further modifying the design to improve its performance were realised by extending the bridle length of the topless trawl from 2.6 to 15.6 m. This reduced the height of the net opening of the trawl (- 0,3m) but also increased the species selection properties for cod and the target species flounder. On two cruises in 2008 on the side trawler Clupea, a loss of 37% of cod and an increase in flounder and plaice catches of 192% and 114% was observed.

Contact: Bernd Mieske (bernd.mieske@vti.bund.de)

Fuel saving of a modified groundgear for cod trawls

A commercial pair trawl groundgear (19.2 m total length) made entirely of rubber plates found no acceptance with fishermen because of its low catch efficiency. UW-observation had shown a big distance between the groundgear and the seabed, which resulted in high escape rates for fish species. A redesign with traditional roller-parts in the middle of the groundgear (6.5 m length) and moving the rubber plates closer to the wings of the trawl lead to the desired bottom contact. In comparison to a standard roller goundgear, engine rpm could be reduced of 100 rpm to reach the same trawl speed of 3 knots. In addition to the reduced bottom impact, a fuel saving of 3.4 litres/hour was observed.

Contact: Bernd Mieske (bernd.mieske@vti.bund.de)

Catch efficiency of set net and cod pots for Baltic Cod

In the Baltic Sea coastal areas of Germany, bycatch of birds and mammals in gillnet fisheries for cod is seen as a problem. Therefore, a series of small scale feasibility studies were conducted to find out whether cod pots could fully or partly replace the gillnet fishery.

Two cruises on FRC Clupea in August and October 2008 were carried out to compare catches of cod with (Norwegian Type) pots set pelagic and on the bottom with catches of gill set-nets fished nearby. No bait was used in the pots. The results for the trials were very disappointing because only one cod was caught in 11 pots. The 50 set-nets showed a mean catch of 12 kg/day of cod and 74 kg/day of flounder. The set-nets equipped with acoustic deterrents showed more catch than the nets without deterrent devices.

One commercial fisherman was also equipped with a limited number of cod pots (8), which were deployed as a string on the bottom in the Baltic near the Fehmarn peninsula. After a short fishing period (six weeks in September/October 2008) he gave up because of handling problems (one-man operation on a small vessel). The results showed only a low catch of cod of 0.06 kg trap/day compared to a mean catch rate of 4.6 kg net/day with gillnets.

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Underwater observation systems

The surface towed intelligent powered vehicle (STIPS II) with wireless transmission of video and control signals was used for groundgear observations on commercial gears in the Baltic. An initiative to re-animate an older 3D maneuverable towed ROV System was successfully used on WHIII to observe a new small sized codend cover for the GOV Survey trawl at the Scottish coast. This ROV System allows the observation of net geometry and fish behaviour along the entire trawl.

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Development of a long range pinger detector for acoustic Deterrents used in the set-net Fishery

Council Regulation (EC) No 812/2004 requires the use of acoustic deterrent devices (pingers) to deter small cetaceans from bottom-set gillnet or entangling nets. However, the regulation does not provide detailed guidance on how the enforcement bodies should control the correct usage and functioning of these pingers. The German and Danish authorities wanted to develop a pinger control device that allowed assessing of whether a set net is correctly equipped with pingers and whether these are functioning. Subsequently, there was the need to enable this without the fishermen necessarily being onsite or retrieving their nets. A Danish company (ETEC-Torben Roenne, Industrivaenget 8a, DK3300 Frederiksvaerk, Denmark, www.Etec.dk) agreed to develop a prototype control device in cooperation with the Federal Research Institute for Rural Areas, Forestry and Fisheries (vTI), Institute of Baltic Sea Fishery and the Danish Directorate of Fisheries.

After a series of prototypes were tested a final version PG1102 (ETEC) was manufactured in October 2008. It was equipped with a Hydrophone TC4033 (RESON) and, was built in a mini-series. Tests with different, cheaper, hydrophones did not give satisfactory results with respect to the detection over longer distances. It was also further equipped with optical indicators (LEDs) for the detected frequency of the signal at nearer distances. The device was designed to display the detected pinger signal visually when the signal was clearly identified. If the signal was too weak then detection was possible via headphones or loudspeaker. Controls and features of the pinger detector amplifier PG1102 (Etec.dk):

The unit

- monitors the frequency range from 700 Hz to 160 kHz
- converts monitoring sounds above the audible range
- can also be used as a conventional underwater sound amplifier
- has an Automatic Gain Control for optimum signal strength
- has a High Pass Filters for attenuation of sea waves and engine noise
- has a Gain Hold Function for suppression of background noise and transients
- can be switched between full range hydrophone signal and frequency conversion
- will handle all passive piezoelectric transducers

The unit provided a detection distance of 400 m which enabled detection of two digital pingers simultaneously when they correctly deployed (200 m distance). The prototype of the new device was tested in 2007/2008 on five cruises (two on Danish FPV Havörnen and two with the German FPV Seeadler and one with FRC Clupea). The tests were conducted with 4 pinger types. Additional tests were carried out in the harbours of Frederiksverk and Cuxhaven in order to check the influence of different background noise on the range of detection of pinger signals.

Pingers were deployed on buoys and their functionality was tested from the vessels Havörnen and Seeadler as well as from dinghies. Distances between the ships and the buoys were measured by radar and GPS. Maximum detection distance was 900 m for analog pinger types (Fumunda, Airmar, and AquaMark 300) and 400 m for the digital AquaMark 100. These detection distances were obtained from dinghies, some distance away from the mother ships. From the Danish inspection vessel Havörnen it was possible to detect the pingers when only the auxiliary engine was running, but the detection distance was lower. The same results were obtained with the German FRV Solea while in harbour and FRC Clupea at sea, however, it was not possible to detect the pingers onboard the German inspection vessel Seeadler. The optical indicators (LEDs) for the detected frequency of the signal functioned up to a distance of 50 m from the pinger. When the noise level was too high or the distance was larger than 50 m, the detection was only possible via the headphones. The final version is envisaged to be available in December 2008 and in the meantime the prototypes are being further tested by the German and Danish authorities.

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15.6 Iceland

Marine Research Institute

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Species selective demersal trawling

The potential for species separation in demersal trawling through the use of horizontal separation panels with upper and lower codend has been investigated. Experiments with various panel positions and mesh sizes of panels have been conducted under commercial conditions. In general, 70–96% separation of cod from haddock was obtained, depending on fish length, rigging and seabed type.

By extending the panel towards the trawl opening, better separation of cod was obtained, but less separation of haddock. Most other species such as redfish (*Sebastes spp*), Wolffish (*Anarhicas lupus*), Saithe (*Pollachius virens*) and flatfish species were retained in the lower codend. Increasing the mesh size of the panel enhanced penetration of fish through the panel, resulting in higher proportion of most species in the upper codend.

Bycatch reduction in *Nephrops* trawling

Large mesh sizes (145–165 mm) in the top panel of a *Nephrops* trawl were tested in three surveys in 2008. A trouser trawl was used in the experiments, with one belly according to the legislation (80 mm mesh size, two 200 mm square mesh panels) and the other belly with larger mesh. All fish and samples of the *Nephrops* catches were measured. The increased mesh sizes appear not to affect *Nephrops*, cod, ling, monkfish and wolffish catches. The square mesh panels were more efficient in excluding haddock than 145 mm meshes alone, but when increasing both the mesh sizes to 165 mm and the hanging ratio, the haddock catches were significantly reduced, only 13%

of the total haddock catches were retained in the codend attached to the 165mm panel.

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

The effect of hook and bait size on fishing efficiency and size composition of cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and wolffish (*Anarhichas lupus*) were investigated in a designed experiment in the Icelandic longline fishery. Five hook sizes, EZ 10–14, and two bait sizes, ~10 and 30 g, were compared. The bait was Saury (*Cololabis saira*). Bait sizes were found to affect catch rates and size selection in the longline fishery for haddock, cod and wolffish. Higher catch rates of haddock were obtained with small bait, but large bait caught cod and wolffish more effectively. The proportion of fish caught with large versus small bait increased significantly with fish size for all three species, and the relationship can be described with a logistic curve. Smaller hooks result generally in higher catches, but there are interactions between bait and hook sizes for cod and haddock; hook sizes affect size selection of cod when small baits are used and haddock selection when large baits are used. The proportion of catches of juvenile fish appeared to be inversely related to fish abundance.

Bottom impact in the seine net fisheries

To investigate the bottom impact of seine nets, a comparison survey was conducted in 2008. A seine net was operated in both areas where seine net had been operated and in areas where seine fishing had been prohibited. The seabed was filmed before and after and biological samples taken.

Attraction and trapping of cod

The objective of this project is to investigate cost-effective ways to trap cod. This is based on direct observation of how cod are caught in traditional traps/pots and can be divided into 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 completed in 2008, no mixtures of amino acids were found efficient unless in extreme quantities. A solution with mixed herring, and even boiled herring mix was found to be effective to attract cod. Building of odour releaser, control units and camera rigging with the ability of remotely control and observe the devices through wireless communication interface is under construction and planned to be tested in May/June 2009.

Electronic logbook

The Icelandic fishing fleet has for many years kept has logbooks with positions, types of fishing gears, estimated catches etc. The fleet is now testing 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 programme has been ongoing for some years, and considerable effort has been allocated to the project to define registration variables and programming.

15.7 Ireland

Bord Iascaigh Mhara, Ireland

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EU DEEPCLEAN Project

The Marine Institute and BIM, together with Seafish and CEFAS have been involved in this EU funded project (DEEPCLEAN) focusing on assessing the extent and effect of lost, discarded and abandoned gillnets on the shelf edge and deepwater fisheries off the coast of Ireland and the UK. Four broad areas were selected for survey: Rockall & George Bligh Bank; North Shetland; South and West Porcupine and; Rosemary Bank & SE Rockall. Charter vessels were selected following an EU wide call for tenders and two vessels were chosen for four surveys. In total, 82 survey days were completed within a four month period during the summer of 2008. Over 2600 km of transects were completed. Detailed information from various sectors of the fishing industry allowed for a number of dedicated mitigation transects, but the majority of transects were randomly generated with depth strata and the survey intensity across strata weighted based on VMS activity.

Of the four general areas surveyed, intensity was highest at Rosemary Bank, with extensive coverage. Coverage in Rockall and Shetland was considered high, but some areas were not surveyed due to unfavourable bottom topography or the presence of sensitive habitats. The extent of fishing activity within these areas is unknown, but VMS data from 2005 indicates some degree of activity. Given the spatial scale of the Porcupine Bank and weather constraints encountered during the survey, survey coverage was considered to be moderate in the southern part of the Porcupine and low to moderate in the western Porcupine. Overall 13 km of gill nets were retrieved, and while this is comparatively low in contrast to other mitigation surveys, the comparatively low levels of a priori data from the fishing industry on precise locations of lost nets is a contributing factor, but given the moderate to high coverage, it is not considered that lost nets are widely distributed throughout the fishing area. No evidence of abandoned gears in any of the areas surveyed was noted. A range of other marine debris was also recovered including trawl warp, trawl netting, communications cable and longlines. Notwithstanding, the survey data implies that the extent of lost nets is not widely distributed and for gillnets that were, retrieved, catches of marine organisms were low and comprised mainly of decapods. On the basis of the level of nets recovered and the catches within them, it is considered that the issue of ghost fishing associated with lost gillnets does not constitute a high source of unaccounted catches.

Environmentally Friendly Fishing Gears

In April/May 2008 trials to generate selectivity data for a range of codends used in the Rockall haddock fishery were completed. These trials were carried out using a kite covered codend and were carried out to measure the selective performance of a standard EU codend of 100 mm with a 90 mm square mesh panel; a 110 mm codend with a 90mm square mesh panel; a 110 mm codend with a 120 mm square mesh panel; and a simulated Russian style codend of 70 mm with a 125 mm cover bag. Results for haddock are reported. The L_{50} for haddock with the standard EU codend was 27.17cm with a selection range of 8.78. By increasing the mesh size of the codend to 110 mm selectivity was improved by almost 2 cm with an L_{50} of 29.6cm and SR of 7.8. By replacing the 90mm square mesh panel with the 120 mm square mesh panel. The selectivity is significantly increased with an L_{50} of 36.72 cm and SR of 19.97. It was noticeable that the 120 mm Square Mesh Panel allowed the escapement of very large fish of between 50 cm and 60 cm. None of the datasets collected with the "Russian" 70mm codend with 125 mm cover bag converged to provide selectivity ogives and it was observed that on all tows virtually no fish were retained in the codend cover. These results indicate the current gear being used in the fishery is not in line with the mls for haddock and that an increase in codend mesh size to 110 mm is appropriate to maintain the haddock stock. The results with the 110 mm and 120 mm square mesh panel arrangement give a selectivity at least if not better than a 120 mm codend.

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 4 sets of trials have been completed with as follows:

- "Supreme II" (Clogherhead) – Celtic Sea/Irish Sea testing a rigid grid, inclined separator panel, and 160 mm Square mesh panel for reduction of cod catches in prawn trawls.
- "Catherine-R" (Greencastle) – Analysis of the impact of new codend mesh sizes (120 mm codend +120 mm smp (12–15 m from codend) for vesssels > 15 m and 10 mm codend +110 mm smp (12–15 m from the codend) for vessels < 15 m required under new regulations in the West of Scotland Area and alternatives to these regulations. Only one option was tested 100mm +120mm codend (5–7 m from the codend).
- "Green Isle" (Greencastle) – Continuation of trials above to assess alternatives which give low cod catches. The options tested against the baseline 120 mm codend +120 mm smp were 110 mm codend +120 mm smp (5–7 m from the codend); 100 mm codend with 160mm smp (5–7 m codend); 100mm codend with 160 mm smp (10–12 m from the codend); and 80 mm codend with 120 mm smp (12–15 m) against 100 mm codend+120 mm smp (5–7 m from the codend)
- "Ocean Pioneer" (Union Hall) – Celtic Sea/Irish Sea testing a 200 mm square mesh panel and a cutaway trawl with reduced top panel for reduction of cod catches in prawn fisheries. (These trials are ongoing).

The data from these trials are still being analysed. Further work looking at an "Eliminator" style seine net with large mesh in the fore part of the net are planned for August 2009.

Environmental Management Systems

A pilot project was completed in 2007 looking at the implementation of a Seafood Environmental Management System (SEMS) for Irish fishing vessels. Following on from this initial project during 2008/2009 a draft SEMS manual was produced and a total of 44 vessels have adopted and completed this SEMS manual including 21 pelagic vessels from north-west port of Killybegs in Co. Donegal. The NW pelagic fleet have successfully completed the assessment for MSC and the SEMS approach played a pivotal role in this assessment being successful. A similar process is currently underway in the south west although there are a number of issues that need to be addressed. On the whitefish side, two vessels have successfully passed the third party audit for the local West Cork regionally Fuchsia Standard with an initial target of 8 vessels being set for the end of the year. These vessels can now use the Fuchsia brand on their fish. All of these processes have assisted in the review of the original EMS manual with revisions to the manual now almost complete. It is due to be reprinted in the next 3–4 weeks. Fishermen are forming a Seafood EMS Fisherman's Association to assist the process be Industry Driven and as a way of controlling and monitoring the use of the EMS system developed.

Fuel Efficiency

As part of an EU funded study a green trawler design has been developed in conjunction with Noel O'Regan of Promara Ltd. The green trawler was designed to have the same characteristics of a typical Irish whitefish vessel but with improved fuel efficient and sea keeping attributes. From tank testing carried out by the Wolfson Unit based in Southampton University and sea trials carried out on a typical Irish vessel in Castletownbere, it has been shown that very substantial fuel savings can be realised with the green trawler design. Savings of 30% on fuel consumption could be achieved with relatively modest length increases. To achieve these savings, however, will require an increase in tonnage of 18% and therefore additional building costs and this currently is restricted by regulations. The final report for this project has been accepted by the EU.

EU Gear Marking Project

A new prototype gear marking system has been developed as part of this project and put forward to the EU as an improvement to the current legislation. In the proposed prototype, the overall length and weight of the buoys has been decreased which provides an effective solution to the problems identified with the size of the original marker buoy. This prototype was compared to the current regulation buoy during trials carried out by BIM in December 2008 as part of this study. These trials looked at the performance of the buoys in differing sea and weather conditions, the practical handling of the two buoys and also looked at the effectiveness of radar reflectors. As part of this study trials with a Radio Frequency Identification system (RFID) have been completed and indicated it possible to transmit data from RFID tags mounted on the buoys and transmit this data to a vessel fitted with a reader unit at a distance of between 150 m to 200 m from the tagged buoy. The final report for this project has been accepted by the EU.

Acoustic Deterrents

Testing of the deterrent devices developed by BIM in conjunction with Aquatec Subsea has been continuing. The latest trials carried out recently on the south coast with bow-riding Common dolphins looked at the effect of the vocalisations from Killer Whales incorporated into the deterrent device. Bad weather and only a single encounter with dolphins meant these results were inconclusive but they will be repeated in due course.

Waste Management

Between November 2007 and February 2008, BIM undertook a comprehensive waste monofilament gillnet recycling project. For the duration of the project, a total of 92 bales were completed, weighing approximately a total of 28 tonnes net weight (without the pallet weight). The bales averaged approximately 200 kg each, and ranged in weight from 150 kg to 250 kg. A forklift was used to transport the bales outside the baling facility, where they were loaded onto a 40 ft lorry trailer, in rows of 2 bales wide and 2 bales high. Two lorry loads of the baled netting were required to remove the 92 bales from the baling facility. These were transported to Petlon UK where they were successfully recycled into various nylon products such as cable ties and office chair components. As part of the project, the BIM staff involved documented all aspects of the baling process in terms of costs, labour, machinery, logistics and transportation. Detailed analyses of the electricity used as well as cost during the baling process were also made as part of the project. A further consignment of 15 tonnes of waste nets was recently shipped to Japan from the site set up in Tramore in 2008. These nets were mainly decommissioned salmon nets although there were also quantities of other gillnets from around the coast. Since 2007 around 50–60 tonnes of netting have now been successfully recycled by BIM, working with a UK Based company Petlon UK at zero cost to the fishing industry. This project is continuing and it is planned a further consignment of 15 tonnes will be ready for shipping in early August. Other waste fishing gear is also being looked at as part of this project.

15.8 Netherlands

Wageningen IMARES Ltd.

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Development of fishing gears with reduced effect on the environment (EU-Project DEGREE)

The MAFCONS-model that calculates the direct impact of two types of bottom trawls (otter- and beam trawl) on the benthic/demersal fish component was completed and published. Further work that allows the application of the model to the benthic invertebrate component consisted of a study to evaluate the effect of spatial scale on the outcomes of the model. The conclusion was that the finest spatial scales achievable with the current VMS data are probably most appropriate. The link with effects on the gear component level is still to be made. Researchers from the FRS Marine Laboratory and the University of Aberdeen worked from the other extreme, modelling the movement and impact on sediments by individual gear components such as clump weights or otter boards verified by experiments *in situ* at sea. The challenge is now to translate this impact into an effect (in terms of mortality) on the gear component level on various marine biota. This effect can then be scaled up to a fishery effect using the MAFCONS model.

The other work in this project concerns Task 4.2 for which during a total of four sea trips on commercial vessels fitted with pulse trawl systems catches and bycatch are being monitored. This activity is planned for the summer of 2009.

EU-Project Energy Saving in Fisheries (ESIF)

This project on energy saving in European fisheries, with participants from Denmark, Netherlands, Belgium, France, United Kingdom, Ireland and Italy was continued and a final report produced for the EU, namely: Marlen, B. van (Ed.), 2009. Energy Saving in Fisheries (ESIF) FISH/2006/17 LOT3 – Final Report. Wageningen IMARES Report number C002/08, 425 pp.

The project aimed at investigating potential technical and operational methods 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. The economic performance of selected fleet segments was analysed with emphasis on the role of energy costs. This economic analysis considered aspects such as: break-even fuel price, factors determining energy efficiency, the economic potential for technological improvement and scenarios for future outlook related to possible development of fuel price. Finally, the economic feasibility of proposed technological adaptations was assessed.

Ongoing national and international research projects show the possibilities of saving energy by reducing the drag of towed fishing gears, changing the design of gear and components, using alternative ways to stimulate fish to be captured, as well as replacement by alternative gear types, including static gears. Some of these projects involved the collection of new data on the detailed breakdown of energy consumption using newly developed fuel measurement devices onboard commercial vessels, e.g. in Italy.

A number of so-called 'reference vessels' were selected by fleet segment for which detailed technical information was collected, often by personally contacting vessel owners. For each of these cases a range of technical adaptations were analysed using an integrated energy systems model. This computer model simulates fuel consumption, efficiencies of the installation, and power used in various operational modes, such as: steaming to and from fishing grounds, shooting and hauling fishing gear, towing fishing gear, and harbour operation. By using this model the percentage change in fuel consumption was calculated for each proposed technical or operational adaptation, relative to the base line vessel operation (i.e. prior to any adaptation). The technical adaptations considered were i.e.: redesigned fishing gears including all their components to reduce drag, applying alternative stimulation in fishing gears to replace heavy bottom chafing material, optimising propeller design, improving hull shape. Also operational changes have been analysed such as: reducing steaming and towing speeds or cleaning hulls more frequently.

The percentage reduction in fuel consumption, with estimates of investment costs for new technology or changed procedures and effects on vessel productivity (landings per unit of effort) were used in an economic model to appraise the economic feasibility of the proposed adaptations and the overall effect on profitability.

The study showed that individual technological adaptations offer energy savings mostly in the range of 5–20%, with a few exceptions going as high as 40% for beam trawlers. In view of the diversity of vessels, gears and fisheries it is not possible to generalize how much savings could be achieved with a completely new fuel efficient design. However, it is most likely that economical investments in such new fuel efficient design are not feasible, as otherwise they would certainly have taken place during the period of high fuel prices. Some segments perform so strongly that they remain profitable even at fuel prices reached in the first half of 2008, between 100 and 140 US$/barrel Brent and up to 0.75 €/litre at the level of the fleet. This applies particularly to passive gears <12m in France and Italy (but not in Denmark) and the (large) pelagic trawlers in the UK, Ireland and in Italy. For almost all other segments for which technical adaptations have been proposed, the break-even fuel price after the adaptation remains (far) below the 2008 fuel price, which implies that these adaptations will improve the economic performance somewhat, but they will not solve the structural problem, which must be sought by raising productivity. The techno-economic analysis shows that for many highly fuel price sensitive fleets, improvement in economic performance can only be achieved through a mix of technical adaptations aimed at reducing fuel use and adaptations aimed at increasing earnings from catches. This implies that the size of the fleets will have to be reduced proportionately in order to ensure that the effective pressure of stocks does not increase.

EU project FISH/2007/07 LOT 3 Impact of Sole and Plaice Gears

The objective of this study with a duration of 18 months is twofold: 1) evaluate the impact of fishing gears currently used to catch plaice and sole in the North Sea, 2) investigate (and if appropriate, recommend) the use of alternative fishing gears for the fisheries concerned. The study began with a first coordination meeting in October 2008 during which a task division was made. A technical review of modified or alternative beam trawl gears, and calculations on emitted greenhouse gases for three Dutch beam trawl fleet segments is being undertaken.

National projects

Studies in relation to the ICES Advice on ecosystems effects of pulse trawling

Additional tank experiments were carried out at IMARES on cat sharks (*Scyliorhinus canicula* L.) using a pulse simulator delivering a stimulus comparable to the *in situ* trawl stimulus to appraise the survival, physical condition and behaviour of these animals under stimulation. The sharks were not transferred from a holding tank to a test tank to avoid additional stress, and a longer period of stimulation was chosen unlike previous experiments. The animals were fixed in three positions from the electrodes. A report is currently being written.

Further experiments were conducted on cod (*Gadus morhua* L.) in a field station at Austevoll in Norway, also with the animals fixed in a cage at three different positions from the electrodes of the pulse stimulator mentioned above. The distances were: 1) a "near field" range with the fish exposed at 10 cm from the conductor element; 2) an "above field" range with the fish exposed at 20–30 cm above the centre of the conductor elements; 3) a "far" field" range with the fish exposed at 40 cm side ways of a conductor element. The tests showed that spinal injuries and even mortality can occur when the animals are close to the electrodes. This is not the case when they remain at distance at the "above field" range. Neither damage nor mortality was found for a control group exposed to a similar treatment, except the electrical stimuli. Additional experiments on invertebrates will be carried out this year.

The Dutch Ministry of Agriculture, Nature and Food Quality (LNV) will contact ICES for further advice on the ecosystem effects of pulse trawling, following the discussions and advice given in 2006. The Dutch fishing industry is currently fitting out a total of five vessels with pulse trawls and winches under derogation from the present ban on using electricity in fishing of the EU (EC Reg. No 850/98 of 30 March 1988). This involves substantial investments by the industry, which will partly be subsidized by the Dutch government. Further implementation in the Dutch fleet depends on lifting the EU ban, emphasizing the importance of a positive verdict from the scientific community. The first vessel in the row MFV TX68 is currently starting to work with the new system.

Reduction of discards by technical modifications of beam trawls

Experiments were carried out in 2007 and 2008 on discard reducing techniques in flatfish beam trawling onboard FRV "Tridens" in close cooperation with the fishing industry. A total of 38 gear tests were conducted in which modified beam trawls were compared in with a conventional 12 m beam trawl. The modifications consisted of a T90 aft part and various Square Mesh Panels (SMPs) in the bottom sheet, top sheet and combinations of both, and variations of a Benthos Release Hole (Figure 4) with a guiding V-panel in the bottom sheet. It was found that a panel in the bottom sheet with 160 mm mesh size appeared to perform best without releasing too many marketable fish. The panel should extend relatively far aft just in front of the codend where the netting is off-ground. Panels placed only in the top sheet are not very suitable in reducing benthos bycatch. In addition the Benthos Release Hole with guiding device seems to be effective in reducing such bycatch. The cooperation between fishermen and scientists worked very well and created better mutual understanding. Further work is advocated to optimise the design of these devices. It is expected that such devices will get wider application in the Dutch beam trawling sector. The findings are given in: Marlen, B. van, Helmond, A.T.M. van, Buyvoets, E., 2009. Reduction of discards by technical modifications of beam trawls. Wageningen IMARES Report C003/09, 70 pp.

Figure 4. Benthos Release Hole inserted in bottom sheet of the port beam trawl, left the guider, right the escape hole

Study of the effect of a By-catch Reduction Panel in a twin-trawl on reducing plaice discards

Comparative fishing trials were conducted in November 2008 on the euro-cutter MFV TH-7 "Adriana Maria" (300hp) on fishing grounds in the North Sea to investigate the effect of By-catch Reduction Panels inserted in a twin-trawl. In a total of 17 experimental hauls with the two nets fished simultaneously, a conventional net on the starboard side and a net with a By-catch Reduction Panel inserted in the top sheet on the port side. The panel reduced the by-catch of juvenile plaice by some 20% compared to the conventional net, but there may be a loss of marketable plaice. However, commercial losses were not confirmed by the skipper when regarding earnings over a longer period. The findings are given in: Marlen, B. van, Helmond, A.T.M. van, Pasterkamp, T.L. and Bol, R, 2008. Study of the effect of a By-catch Reduction Panel in a twin-trawl on reducing plaice discards. Wageningen IMARES Report C106/08, 19 pp.

VIP-projects

A number of new national projects, proposed by groups of fishermen in the Call of March 2008 of the Dutch Fisheries Innovation Platform (NL: VIP), were granted and commenced in 2008 in which IMARES (together with ILVO Ostend Belgium) plays a scientific guiding role.

Project **HydroRig** involves the development of hydro-mechanical stimulation in beam trawling for flatfish to replace tickler chains or allow lighter chain arrangements to be used in order to reduce fuel consumption and bottom impact, comparable to the development of a hydro-dredge by M.I.T. Boston, Mass., USA, presented during the ICES Symposium "Fishing Technology in the 21st Century – Integrating Fishing and Ecosystem Conservation" in Boston, USA in November 2006. Flow field calculations (2D) show localised increases in velocity and decrease in pressure beneath the foil, depending on the profile shape and angle of attack. The question is whether these can stimulate flatfish to leave their buried position in the seabed, leading to capture. Experiments will be undertaken in June 2009 in the a sediment-water tank of Deltares in Delft, Netherlands on various profile shapes to study water flow induced stimulation, followed by sea trials and observations later this year.

Project **Outriggen 2008** aims at improving the catch rate on sole in fishing with outrigger trawls (Figure 5) replacing beam trawls, whilst reducing fuel consumption and bottom impact. The project is being run on two beam trawlers, MFV NG1 "Jurie van den Berg" (1350hp) and TX5 "Arie Senior" (2000hp). Lower fuel consumption was achieved, but due to lower catches of sole, the gross earnings were also reduced. Additionally the companies promote their fish products (mainly plaice, (*Pleuronectes platessa* L.)) having better quality and caught by a more ecosystem-friendly method, and hope for better prices. A second series of sea trials will be conducted later this year.

Figure 5. Outrig-gear used on MFV NG1 in October 2006

Project **SumWing** (http://www.sumwing.nl/) involves the optimization of a hydrodynamically shaped beam to replace the conventional cylindrical ones used in beam trawling in order to reduce gear drag and fuel consumption (Figure 6). In addition beam trawl shoes are left out, creating a construction that 'flies' over rather than in direct contact with the seabed. The gear is guided by a 'nose' construction running over the seabed thus ensuring that it follows undulations in the sea floor. Comparative fishing trials were conducted during two weeks in October 2008 on two sister beam trawlers (TX36 "Jan van Toon" and TX38 "Branding IV", both around 2000hp), and showed no distinct differences in the catches of target and non-target species. Measurements on fuel consumption showed a decrease of about 11% with the SumWings compared to a conventional cylindrical beam with trawl shoes, with tickler chain arrangements kept the same. The idea is to integrate this technology with pulse trawling, thus creating a larger energy savings potential. A follow-up project in the VIP-scheme has been proposed.

Figure 6. SumWing, design for Euro-cutters

These projects are continuing and reports will be produced by the end of this year.

Meanwhile new initiatives are also being started, such as a proposal on development of a pulse beam trawl for brown shrimps (*Crangon crangon* L.), one on static gear development, and one on an integrated data collection and decision support system for Dutch beam trawlers.

15.9 Norway

SINTEF

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 the 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. The air bubbles are released by a sparger system towed at 40 m depth or less. The 'lifting' can be achieved by two different mechanisms, namely flotation and upwelling. Flotation means that air bubbles attach to the *Calanus* body and lift it by buoyancy. Upwelling means that a lot of bubbles are generated to induce an upward water transport, bringing everything that naturally follows the water with it towards the surface. The project has included laboratory studies of pure bubble hydrodynamics as well as high speed video capturing and analysis of interaction between bubbles and live *Calanus*. So far the upwelling mechanism appears most promising, although attachment and flotation of individual *Calanus* has also been observed. Field tests will be carried out in the spring of 2009. A parallel project has been initiated to investigate applying the same technology to generate upwelling and subsequent surface out welling for use in oil spill recovery operations.

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

A new project to be started in 2009, has 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 shall propose new rational fishing strategies and develop new, feasible gear concepts in close cooperation with fishermen and the fishing industry, through workshops, lab tests and numerical simulations, including aspects such as net design, towing resistance and catch efficiency.

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Model based surveillance of trawl systems

The submerged parts of the trawl systems cannot be directly observed, and the available measurements are often few and unreliable. To address this issue, SINTEF Fisheries and Aquaculture are developing a state estimator based on a mathematical model of the system. The mathematical model is used in a simulation running in parallel to the real system. The simulation is thus able to improve existing measurements in terms of both precision and update rate, as well as to provide information which is not, or cannot be, measured. The information provided may include any position and velocity in the trawl system, such as trawl door orientation, wing spread and wing positions, as well as information about the bottom pressure and symmetry of the trawl. The model is improved and adapted to the actual system by using the available measurements. This project is part of a project run by RollsRoyce Marine, where the goal is to develop a control system for trawl winches which can take the additional available information into account. Offshore Simulation Centre, Ålesund is also part of the project, and is responsible for the 3D visualization of the trawl system.

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Optimization of bottom trawl gear with respect to energy consumption

Fundamental research has been performed to achieve more knowledge on the hydrodynamic properties of net panels and rockhopper groundgear, and improved mathematical descriptions of the hydrodynamic loadings will be developed based on the experiments performed in the flume tank. Flume tank experiments with a trawl net were carried out as well, and response forces were measured as a function of the trawl opening's width and height. The hydrodynamic loading models will be verified by comparing such experiments to numerical simulations with these new loading models. A new computer tool for simulating net structures is being developed, and will be used for this comparison. Model scale experiments with trawl door bottom impact have also been performed, and these will form the basis for the development of new structureseabed interaction models. In order to make such research results available for daily operation of bottom trawls, a computer tool has been developed for studying the effect of changes in the rigging of the gear. The latest models and mathematical descriptions are included in the tool, enabling the fishermen to investigate how changes in important parameters like weights, floaters, door sizes, net mesh sizes etc. influence on the geometry and towing resistance. This computer tool may help the fishing fleet to optimize the equipment to their current operation conditions. The project is funded by the Norwegian Research Council and The Norwegian Fishery and Aquaculture Industry Fund.

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The trawler of the future

The project started in 2007 and is due to be completed in July 2009, with the objectives to reduce fuel consumption and to improve safety on the trawl deck. The project is supported by the Norwegian Research Council and The Fishery and Aquaculture Industry Research Fund since 2007. The participants in the consortium consist of Rolls-Royce Marine, several fishing vessel owners and Sintef Fisheries and aquaculture.

From the model tests that have been conducted with a model of a "conventional trawler" and a model of a "future trawler" it is shown that significant fuel savings can be achieved with hull modifications and by changing from one propeller to two propellers. Results from model tests and calculations also show that fuel savings can be achieved by transverse movement of warp blocks to unload rudders in demanding trawl operations in bad weather. The fuel savings effect from utilizing the heat in exhaust gas and engine cooling water by using a heat recovery system (ORC – Organic Rankine Cycle) has also been calculated. If all the initiative to save fuel are taken into use it is possible, in average, to save 25% fuel and installed power can be reduced by 32%. Diesel electric propulsion is more effective than earlier calculated for trawlers when diesel electric propulsion is installed in combination with ORC. The locations of engines are more flexible with diesel electric propulsion and thus the general arrangement of the vessel can be more effective. Several concepts have been developed to increase the effectiveness and security of the trawl gear handling.

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Physiological and behavioral indicators of fish welfare

Laboratory experiments were conducted with the aim of constructing a RAMP (reflex action mortality predictor) curve for prediction of vitality and survival potential in Atlantic cod captured in Danish seine, by varying the levels of swimming, net abrasion, and air exposure. Atlantic cod exposed to increased duration in air (5–20 min) showed increased reflex impairment and mortality, with 75% mortality at 10 min. air exposure. Forced swimming in combination with net abrasion and aerial exposure did not increase reflex impairment or mortality above that associated with aerial exposure alone. The Atlantic cod RAMP curves indicated that fish with reflex impairment less than 50% would not show mortality and would likely recover from capture stress.

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Fish welfare in capture based aquaculture

Field experiments focusing on determining fish condition and survival potential of longline caught and pot caught cod using physiology (lactate, glucose, cortisol and pH) and reflex testing at capture were conducted during autumn 2008. For both gears up to 90% of captured fish were floating (owing to surplus gas in abdomen due to swim bladder puncture) and were not fit for CBA purposes. Of the remaining cod, longline caught cod were more stressed than pot-caught cod as measured both by increased levels of physiological stress and higher reflex impairment. A 14 day post capture holding experiment revealed improvement in reflex scores for cod caught by both gears, indicating recovery from capture stress and acclimation to tank environment.

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Increased transport capacity for Danish seine fishing vessels targeting cod for CBA purposes

In April 2008 and 2009, field experiments on board a Danish seiner were conducted in order to investigate the effect of increased resting area on the vessel's transport capacity of newly caught live cod. Immediately post capture, a large portion of Danish seine caught cod rest at the bottom of transport tanks in order to recover from capture and handling stress. Cod lift from the bottom gradually (from a few hours to a few days) as physiological and behavioural control is regained and the resting area gets available again. During the resting phase, available bottom area is the decisive factor for the capture rate (kg/per day) which the vessel can maintain, as fishing has to cease when all resting area is occupied. By mounting a vertical separator floor dividing the fish tank in two equal volumes, the resting area was doubled. The effect of increase in resting area was tested in several experiments. Results showed that the transport capacity of the double floor tank could be increased by at least 50% contra single floor tanks.

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Mid-water trawling for gadoids in the Barents Sea

Due to increased concern about bottom impact from bottom trawling, research is being carried out to verify if mid-water trawling techniques can be an economical and sustainable method for catching gadoids for the trawler fleet. 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 front have been built for the experiments. Commercial catches of large cod (no undersized fish) were taken during fishing trials onboard a chartered commercial trawler in May 2008. During a research cruise in October 2008 the trawl was fished with a tandem grid arrangement that proved highly efficient at sorting out undersized fish which made up the bulk of the pelagic distributions of cod in the area. Behaviour of fish during the capture phase by pelagic trawl differed from that observed in bottom trawling. Netting of capelin in mesh section < 400 mm was shown to be practically eliminated by the use of T90 netting. The fishing trials indicate 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 trawl.

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Unaccounted mortality in purse seine fisheries for North Sea Herring

In the purse seine fisheries for pelagic species such as mackerel and herring, it has been the practise to purse the catch taken by the seine towards the vessel side for inspection. If the species, size or quality is considered unsatisfactory, the catch is released. Slipping may also occur if the catch is too big, or if the seine breaks. In May 2008 a first field experiment was conducted to study the mortality of North Sea herring after crowding and slipping. The experiments were carried out onboard commercial purse seine vessels in the open sea. It was shown that the mortality was dependent on the degree of crowding. Further experiments are required to provide reliable mortality estimates.

Contact: Aud Vold; aud@imr.no

Degree

In the EU project DEGREE (Development of Fishing Gears with Reduced Effect on the Environment), an international survey was conducted onboard RV "G. O. Sars" to compare a "new" trawl system developed during the project to the standard trawl used in the fisheries for cod in the Barents Sea. Both systems consisted of the same trawl net, but the "new" trawl was rigged with a new plate gear, bobbins always rolling in the towing direction and the trawl doors barely touching the bottom. The standard trawl had a heavy rockhopper groundgear and the doors were fished heavy on the bottom. ROV-inspections of the sea bed after trawling combined with trawl instrumentation data showed that the bottom impact of the "new" trawl was significantly less than that of the standard trawl.

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Analyses of catch data to investigate the effects of geophysical activity on fish catch rates

Official catch statistics were used to investigate the possible effects of 2D seismic shooting with air guns on the local fisheries in the Lofoten/Vesterålen area in northern Norway summer 2008. Catches taken during shooting were compared to those taken in the same period previously 5 years ago, as well as in the months before and after shooting. The data bases used were not very well suited for the analyses, as they were not sufficiently detailed in time and space, as well as in effort information. It was shown, however, that the total catch of saithe was reduced by about 45 % in the investigation area in 2008 compared to the previous years, and also that the catch rates of saithe and haddock in gillnet fisheries were reduced. No significant reductions were found for other species or fishing gears (longline, hook-and-line, Danish seine).

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Cod pots

Comparative fishing experiments have been carried out to test different entrance designs and the effect of additional stimuli in cod pots. No difference in catching efficiency was found between triangular and square openings in the entrance. Using a plastic streamer as a visual stimulus in addition to baits did not increase the catching efficiency either. Several small scale fishing trials are being carried out on board commercial vessels in order to identify areas and seasons where pots have a potential as an alternative fishing method in the coastal cod fishery.

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Reduced by catch of saithe in the bottom trawl fishery for blue whiting

The trawl fishery for blue whiting and Norway pout along the Norwegian Trench has for many years been associated with bycatch of saithe and to some extent haddock. Experiments carried out in 2008 with both flexible and rigid grid systems with 40mm bar spacing have proved to reduce the bycatch substantial. While a flexi-panel gave a loss of the target species of about 3–5 %, the steel version of the grid gave less than 1% target species loss. Bycatch reduction of saithe is even better for the steel grid, sorting out more than 95 % of saithe compared to 85–90% with the flexi-panel. This difference is explained by the possibility of a varying bar spacing in the flexi-panel. From 1 January 2009, the trawlers are allowed to have a maximum of 5 % mixture of saithe (by weight) in the landings of blue whiting. This implies that the trawlers have to use a grid device to comply with the rules.

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Whitefish by catch in the trawl fishery for spawning capelin

After years of the capelin fishery off the coast of Northern Norway being closed, the commercial fishery for this species opened again in March 2009, both by purse seiners and pelagic trawlers. Earlier years experience with big bycatch of cod and haddock in the trawl fishery was often followed by a closure of the fishing grounds. The Directorate of Fisheries expressed an interest in the possibility to avoid these problems by using a grid sorting system. However, with catch rates of up to 100 tonnes per minute of capelin gave rise to substantial loss of the target species, and further experimentation with grids in this fishery was stopped. Future regulation of this fishery has to rely on closure of sensitive areas therefore.

Some good footage was obtained of capelin escaping from the trawl, showing a substantial amount of "stickers" in net sections with mesh size from 40 to 500 mm. Footage of capelin inside the trawl indicated that the capelin focused more on the schooling behaviour than reacting to the trawl, and maintained a reaction distance to the net panels. It is therefore an open question regarding the benefit of using big meshes for herding specie like capelin.

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Small redfish in the deepwater trawl fishery for pink shrimp – impossible to avoid

In spite of a convincing reduction of bycatch of different species when using the Nordmøre grid, catches of small juvenile redfish are still a serious problem in many of the North Atlantic shrimp trawl fisheries. Experiments (2005/2006) with different net panel arrangements in the extension piece or codend have given varying results, depending on time and area (coastal or offshore areas). Close up video observations in 2008 of 10–12 cm juvenile redfish did show poor swimming ability, and almost no escapement reaction to the Nordmøre grid. Redfish fry of 7 to 12 cm are swept through a grid just as quick as the target species. Experiments with a narrower bar spacing (15 mm) have given better release of redfish juveniles above 10 cm, but do indicate an increasing loss of the biggest shrimp.

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15.10 Portugal

INRB I.P./IPIMAR

Survival of Norway lobster escaping from diamond and square mesh codends

This study started in 2007, with the first experiments carried out in July, onboard a crustacean trawler, and continued in 2008, with further trials carried out in August and November. Survival of Norway lobster escaping from trawl codends was estimated in summer and winter conditions, using a diamond codend of 70 mm and a square mesh codend of 55 mm mesh size. Catch fractions from both codends were maintained onboard in cold and humid environment to evaluate survival and quality of individuals captured and to assess the: existence codend type related differences.

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Dynamics of the coastal trawl fleet

Fishing activity was described for the coastal trawl fleet. In addition to the two main FC, comprising the 'fish' and crustacean trawlers, a group of trawlers seasonally engaged in the catch of cephalopods, alternating landings for these species with those of horse mackerel and other semi-pelagic fish species. Temporal and spatial patterns of activity were defined using data from three consecutive years. Geo-referenced information from the Portuguese vessel monitoring system (MONICAP) combined with landings data were used to model the fishermen's individual decision to return to the fishing ground of the previous trip.

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Automatic identification of *Nephrops* from video images

INRB/IPIMAR and IST-IT (Institute of Telecommunications, Lisbon) have been working since 2007 on the use of image analysis techniques to arrive at a computer-based procedure to assist scientists in the counting of benthic organisms. The primary objective is to evaluate the possibility of automating *Nephrops* and their burrows counting for population abundance estimation. Video footages taken by Kongsberg Maritime OE1324 monochrome SIT low-light, high-intensity camera hanged from a survey trawl headline towed at the deepwater fishing grounds off the Portuguese coast. The results are promising although the identification of burrows (the basis for *Nephrops* abundance estimation from TV-surveys) constitutes a major challenge.

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Acoustic surveys for seabed mapping

INRB/IPIMAR has been surveying the seabed off the Portuguese mainland coast in order to produce maps with application to fishing activity and management of the marine environment. Acoustic techniques are used for a broad characterization of seabed physical attributes related with habitats, namely bottom topography, bottom roughness and backscatter patterns. Digital terrain Models (DTM), from which maps and 3D representations are generated, have been developed using spatial interpolation. Based on this activity, mapping of deepwater (600–1500 m) and coastal zones in the Portuguese mainland ZEE were obtained.

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15.11 Scotland

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Trials to reduce cod by-catch by modification of a commercial whitefish trawl to incorporate large meshes in the lower wings and belly sheet

Trials took place on two commercial vessels, the Caspian (BF 38) in June 2008 and on the Genesis (BF 505) in December 2008 to identify whether incorporating 800 mm diamond mesh panels in the trawl's belly sheet of commercial trawl nets can provide an escape route for cod but still allow other commercially important ground fish such as anglerfish, megrims and lemon sole to still be retained. Three different configurations were considered. The Caspian trials investigated two of these cases. In the first, an 800 mm diamond mesh panel was inserted into the first belly section of the trawl, while in the second; an additional 800 mm panel was inserted into the belly section immediately behind the first one. The Genesis trials investigated a third case which consisted of two 800 mm diamond mesh panels inserted into the sides of the of the trawls belly section.

There was no loss of catches of haddock and whiting in any of the three test gears and no loss of cod when using the first gear of the Caspian trials. In contrast there was length dependent selection for cod in the two other gears: the relative catch rate of the second Caspian gear increased from about 36% for 32 cm fish to 56% for 77 cm fish; while that of the Genesis gear increased from about 15% for 32 cm cod to 42% for 49 cm cod. There was also evidence of losses of monkfish and megrim through these latter two gears.

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The effects of square mesh panel mesh size and position on the selectivity of high and low powered *Nephrops* trawlers

Following discussions with the fishing industry, North Sea skippers proposed a study, under the 2 call for proposals of the Scottish Industry Science Partnership, to measure the selectivity of 110 mm and 120 mm square mesh panels (SMPs) of 3 m length in 80 mm codends in order to improve whitefish selectivity in *Nephrops* trawls. In particular, it was proposed that this study would assess the differences in performance

- between SMPs placed in the straight extension or in the taper,
- between 110 and 120 mm SMPs, and
- between gears towed by vessels of different horsepower.

Two commercial charter trials were carried out. The first took place for 15 days in April on the higher-powered (500kW) Zenith (BF106), and the second took place for 12 days in August 2008 on the lower-powered (298kW) Bountiful (BF79).

The results of the trials indicate that

- Compared to an 80 mm codend with no SMP, all cases with a SMP improved the selection of haddock and whiting.
- Increasing the mesh size of the SMP from 110 mm to 120 mm was sometimes shown to improve the selection of haddock.
- Positioning a SMP in the straight extension of the net rather than the tapered section improved the selection of whiting and was sometimes shown to improve of haddock.
- Catches of haddock or whiting were not affected by the power of the vessel.

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Effect of vessel horsepower on the selectivity of *Nephrops* trawls

The purpose of this project was to study the selectivity of juvenile fish and *Nephrops* caught by *Nephrops* gear on two vessels with different horsepower. Is anecdotal evidence correct to suggest that gears towed by low-powered vessels are more selective than those towed by high-powered vessels? The assumption is that higher powered vessels can fish at faster towing speeds giving juvenile fish less opportunity to make escape attempts. There is also a perception that, in poorer sea states, greater power enables a vessel to maintain tension on the gear, making the codend less selective. Mallaig and North West Fishermen's Association proposed a study to compare the selectivity of low- and high-powered vessels as a project under the Scottish Industry Science Partnership.

A 12-day research charter was commissioned to acquire data on the selectivity of juvenile fish and *Nephrops* when fishing on *Nephrops* grounds off Mallaig. Two vessels, the Margaret Ann (low power) and Ocean Trust (higher power), carried out parallel, simultaneous fishing tows using *Nephrops* gear with 80 or 100 mm codends and 200 mm mesh square mesh panels (SMPs) fitted in the extension, 15–18 m from the codline, and extending 8 meshes into the taper of the net.

Contrary to anecdotal information, there is no evidence that gears towed by a low-powered vessel are more selective for haddock, whiting and *Nephrops* than those towed by a higher-powered vessel. There is also no evidence of a difference in the catching performance of the two codends for haddock, whiting and *Nephrops*. The low-powered vessel retained more hake than the higher-powered vessel and the 100 mm x 5 mm double twine x 100 open meshes codend retained more hake than the 80 mm x 4 mm single twine x 120 open meshes codend. There is no evidence that *Nephrops* escape through the 200 mm square mesh panels positioned 15 to 18 m from the codline.

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Evaluation of the catching ability of the GOV Trawl against that of a commercial type trawl

Twin trawl catch comparison trials comparing the catch performance of a survey net (the GOV) and a commercial white fish trawl were carried out in May 2008 on the MFV Russa Taign. Sixty six hauls were carried out with the nets fishing together in a twin trawl configuration. Generally, the two nets showed similar catch performance. The GOV had statistically significant better rates for cod, lemon sole and hake. The commercial net was significantly better for plaice, while both nets caught roughly the same amount of haddock. There were no length dependent differences in the catch of these species. There was a length dependency in whiting where the GOV caught more small fish (<25 cm) and the commercial net caught more large fish. The commercial net also caught more saithe, megrim and angler fish, however, these differences were not statistically significant. Haul by haul catch bulk followed the same trend in the two nets for haddock, plaice and lemon sole. There was no clear relationship for cod and whiting, possibly due to aggregation during trawling.

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Meta analysis of Scottish haddock selectivity data.

Haddock selectivity data collected between 1991 and 2005, on Scottish whitefish vessels was collated. These data comprised 550 hauls carried out on thirty trips using pair seine (1), pair trawls (2), single trawls (15) and twin trawls (12). The covered codend was used in all single and pair trips and the twin trawl methodology on twin trawl trips.

The relationship between the selection parameters (l50 and log SR) and the explanatory variables was investigated using linear mixed models (e.g. McCulloch & Searle, 2001) in a backwards and forwards stepwise selection process. Nonlinear effects were also investigated by fitting cubic smoothing splines (Verbyla *et al*., 1999) or by binning a continuous variable and treating it as a categorical variable. The significance of the fixed (linear) effects was assessed by Wald tests; the significance of the random effects and of the cubic smoothing splines was assessed by analysis of deviance. This work is being written up for publication.

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Fish Pot Development

Three small scale exercises were undertaken in 2008/2009 to develop fish pots as a survey tool. The first two trials were conducted in coastal waters (depths <70 m) near Buckie, Scotland, in September 2008 and January 2009. Both of these trials focused on specific pot design concepts, including entrance design and the number of retaining compartments in the pot. The third exercise, in April 2009, was in support of a research cruise on RV Alba na Mara dedicated to developing survey techniques for inshore waters (in & 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).

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15.12 Spain

Institute: AZTI Tecnalia

Fishing Technology related projects carried out at AZTI Fundación (Technological Institute for Fisheries and Food; www.azti.es) by the Marine and Fishing Gear Technology Research Area.

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Field study to assess some mitigation measures to reduce bycatch of marine turtles in surface longline fisheries (project Ref. No. FISH/2005/28A)

This project involving fishermen is testing hook and bait types in European surface longline fisheries targeting swordfish in the Atlantic, eastern and western Mediterranean with the aim of assessing whether they reduce turtle bycatch. The trials were conducted in collaboration with the fishing industry in the following fisheries:

- Greek longline fishery in the eastern Mediterranean
- Spanish longline fishery in the western Mediterranean
- Spanish distant water longline fishery in the south-east Atlantic Ocean

Two longlines were set each day, one with squid bait and one with mackerel bait, and each with alternating magazines of J hooks, 0º offset 16/0 circle hooks and 10º offset 18/0 circle hooks. A total of 124 turtles were caught in the trials — 9 leatherback turtles and 115 loggerhead turtles. More loggerhead turtles were caught in the Atlantic and western Mediterranean (36 and 77 respectively) than in the eastern Mediterranean (2). Turtle bycatch was significantly affected by bait type. Turtles were consistently caught more frequently on squid bait than on mackerel bait, and 82% of all loggerhead turtles were caught with squid. There was no significant difference in turtle bycatch rates between circle hooks and J hooks, although there was an indication that 18/0 circle hooks were less likely to be swallowed than J hooks or 16/0 circle hooks and, in the western Mediterranean, that turtle catch rate on circle hooks was slightly lower than on J hooks. Swordfish catch rates were not significantly affected by bait type in any region. However, hook type did have an influence in the western

Mediterranean, with significantly higher catch rates of swordfish on J hooks compared to circle hooks. The size of swordfish caught was not affected by hook type, but bait type did have an effect in the western Mediterranean, where larger swordfish were caught on squid bait compared to mackerel bait. Effects of hook and bait on other species caught during the trials as secondary target species or bycatch were also monitored. Bluefin tuna catches were significantly lower on mackerel compared to squid bait in the western Mediterranean.

Development and testing of a semi- automated rod for the pole and line tuna fishery (AZTI project ATM2006CAÑA_CIM)

The pole and line artisanal tuna fishery with live bait requires a large crew to operate the pole manually to catch tuna (Albacore and Bluefin tuna). The aim of the project is to develop an automated rod prototype which can substantially reduce the man power needed for the fishing operation, as well as to minimize operational risks relating to hooks and physical exertion (back injuries). A first prototype has been designed, built and tested in the commercial fishery during the summer tuna fishing in 2005. As a result of the fishing trials with the prototype, several technical improvements have been identified and defined in terms of technical specifications. Two more improved prototypes were built in 2006 based on the reviewed technical specifications. They have been tested in the commercial tuna fishery in summer 2007 with success both in terms of reduction of man-power for similar catching performance to the classic pole and line manual operation and of increasing safety during fishing operation. During 2008 some tests were made on board pole and line fishing vessels and the results showed a reduction in the man-power needed with no major reduction in catchability. During 2009 the implementation of the automated rod is being carried out in the pole and line fleet segment.

Analysis of the acoustic spectrograms of tuna fishing vessels (AZTI project ATM2006RUIDO)

Vessel noise to minimise fish avoidance to the vessel during fishing is an important factor to be taken into account in the fishing performance of artisanal tuna fishing vessels using trolling lines as well as pole and line with live bait. The objectives of the study are to establish a standard procedure for the measurement of noise radiated by commercial vessels using hydro-acoustic equipments; to define the noise pattern of different categories of vessels; to define the noise characteristics that have an influence on fishing performance according to sound and vibration sensitivity of tuna species. Different measurement operations of commercial fishing vessels were carried out during 2005, 2006 and 2007, building a database of noise recordings of the fleet. Noise recordings were processed to obtain sound pressure levels and frequency spectral compositions. The project has been carried out in consultation with the technical staff that record the acoustics of fishing vessels every year by studying their air radiated noise. The long term goal of the study is to be able to establish the underwater noise pattern of those mechanical deficiencies in the vessels detected by aerial noise recording.

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 the fuel efficiency in fishing vessels. In order to characterize accurately the pattern of fuel usage onboard, a complex consumption measuring system has been designed, capable of recording not only the fuel consumption but also many other interesting variables, such as the wind force and direction, the exhaust gas temperature, the rolling and pitch movements and the vessel speed among others. 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 on 4 vessels from 3 fleet segments were the 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 of the fishing segment. After this period several different conclusions have been reached. The main conclusion was that it is not necessary to use such complex system to bring benefits to the user and now a low cost system is now being developed that will assist the fleet in fuel consumption management on board.

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

Thinner and robust netting materials are available on the market for the construction of fishing nest that can reduce the drag of the trawl and hence improve the energy consumption of fishing vessels. A modified design of a commercial bottom trawl net has been designed and built with the half upper part of the trawl replaced by high tenacity polyethylene netting excepted for the codend. Preliminary trials at sea were carried out in 2006 to establish the working method for the assessment of the hydrodynamic performance of the trawl system, its catching efficiency and the level of fuel consumption of the towing vessel during fishing. The preliminary trials point out that there is margin for fuel consumption optimisation 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. Experimental fishing trials are scheduled in 2009 to evaluate net geometry, catching performance, fuel efficiency and operation on deck for the new trawl.

Viability study on the potential to improve fuel efficiency in fishing vessels of the application of renewable sources of energy (solar & eolian)

The trend of increasing fuel prices is one of the most serious threats that the fishing sector has had to face in the short term. This research aims at studying the potential of the use of renewable sources of energy (solar: photovoltaic plates; eolian: wind vane layouts; sail assistance) to reduce fuel consumption on fishing vessels. The pilot study is focusing on a trolling line type vessel due to its long running hours during the tuna fishing season. The electric power generation of possible solar plate and wind vane layouts has been calculated. Studies are being carried out to determine the maximum sail area and describe the necessary changes so that adequate stability is maintained. Apart from estimating (or measuring in case of installing sails in a prototype) the fuel saving achieved by the use of sails as an auxiliary power source, the roll reducing effect of the sails will also be studied. The preliminary results show that at this moment these renewable energies are not feasible. Further work is considering how waste heat can be recovered from the engines.

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 designs in order to reduce fuel consumption, either optimizing the propulsion 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 attending to the hull design and the fishing operation. A sample of several fishing vessels, representatives 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 over the duration of this project, the 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, in the same way a propeller matched to hull design helps in fuel efficiency improvement and finally a correct trimming of the vessel is another important factor for achieving this objective.

Characterization, test and improvement of the fishing lines (PA) used by fishermen in fishing gears with hooks

Hooks are widely used throughout the Basque Country artisanal fisheries. The hook is always attached to a PA monofilament line in all the fishing modalities be it (Longline, handline, pole and line). The breaking strength of the PA monofilament is one of the most important physical characteristics for the fishermen. This parameter is often given by PA line manufacturers but it is not well know the conditions in which they carry out this testing (e.g. in presence or absence of knots, the material is wet or not). In this experiment, scale models of fishing gears were manufactured respecting the rigging used by the fishermen in several brands and diameters. The results obtained give the technical features for the tested lines in conditions closer to fishing operations and determine that the knot is the weakest point of the rigging.

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

In this 2 year project starting in 2009 attempts have been made to reduce discarding in bottom trawlers operating in ICES VIIIabd by means of selective devices. In the first steps of this project an underwater video camera will be set in different parts of the trawl to study the behaviour of different species of fishes. The footage obtained with the camera will contribute to the position and design of gear modifications to be tested in relation to fish behaviour.

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

In this 3 year project starting in 2009 a characterization and quantification of the discards in the different artisanal metiers will be carried out in order to identify fisheries with the highest discard rates. Following on from this an analysis of the possible methods to reduce the bycatch of the most frequently discarded species will be undertaken. Finally, fishing trials with the selected methods for reduction of the bycatch of discarded species will be tested.

15.13 United States

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

This project uses underwater video cameras to develop an effective spiny dogfish (*Squalus acanthias)* excluder in a whiting (*Merluccius bilinearis)* raised footrope trawl net. Preliminary underwater filming was conducted in October and November 2008. A total of nine tows were completed and approx. 12 hours of underwater video were collected. Observations and fishermen's feedback during commercial fishing indicated that the grate was effective in releasing dogfish and retaining whiting. Additional fieldwork planned for spring 2009 will examine different grate angles and colours.

Determining the Seasonality of Cod Pots

We are attempting determine the seasonal vulnerability of Atlantic cod (*Gadus morhua)* to two types of fish pots (Newfoundland and Norwegian designs) in Massachusetts Bay. Fieldwork began in December, and continued for brief periods in subsequent months. Twenty-three sea days and one aborted trip were completed, with some cod catches in both pot types; so far, April catches were highest: ~120 fish in 54 overnight soaks. Field work will continue at least until June, with underwater video as possible. Healthy cod are tagged by University of Massachusetts scientists with t-bar tags and depth-salinity-temperature tags if spawning. Fin clips to determine genetic relationships among subpopulation of cod are also collected.

The Five Point Trawl

We continue to explore the potential for a sweepless raised footrope (semi-pelagic) trawl net to target haddock (*Melanogrammus aeglefinus)* and avoid cod with a simple, low-impact trawl design. An investigation of the stability of the net was conducted in 2008 using video imaging from a towed underwater vehicle, and net mensuration equipment. Net geometry appeared to be stable under multiple conditions. Preparations were made to complete field testing in late spring 2009.

Gillnet Selectivity for Monkfish (*Lophius americanus)*

Lognormal selectivity curves were fitted to monkfish gillnet catches in 10, 12, and 14-inch (254, 305, 356 mm) stretched-mesh tied-down bottom gillnets using SELECT and REML methodology. Modal lengths for the mean REML curve were: 62 cm (spread: 10 cm); 75 cm (spread: 12 cm); and 87 cm (spread: 12 cm) for the 10, 12, and 14-inch (254, 305, 356 mm) mesh sizes. Depth was a significant but minor factor in modal lengths of monkfish at each mesh size, resulting in ± 1 cm differences in the modal lengths. Twelve inch mesh appeared to maximize catch of premium priced monkfish (8+ lbs (3.6 kg), minimize catch of smaller monkfish, and increase desired catch of larger skates.

Factors Affecting Trap Hauler Design and Tuning

An investigation of different components of the lobster pot hauling processes suggests that modifications of equipment may extend the service life of sinking line required by regulations designed to reduce whale entanglements. Different hauler sheaves, splitters, and hauler adjustments affected rope wear. Surface treatment (grinding v. stamping) appeared to have a large impact on line strength. Sinking line constructed from blended polyester and Polysteel showed greater loss of breaking strength compared to floating rope constructed of straight Polysteel, confirming observations by lobstermen. However, this loss was not related to sediment load as had been expected. Spacing between stamped steel sheaves caused more rope wear for the floating line, perhaps due to variable angles in the sheaves. Modified splitters that decreased the contact angle appeared to improve longevity of sinking line. Polyurethane splitters were as durable as steel splitters, and easier to smooth. Polyurethane sheaves gripped lines well, but were not adequately durable.

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

Prior research in this zone suggested that Norbait 700E might reduce cod bycatch in a longline fishery targeting haddock. A five-boat experimental fishery using Norbait only was permitted in April 2009; preliminary results suggest that cod bycatch was substantially lower than predicted by experimental results (~3 haddock per cod), averaging approx. 47 haddock for every cod.

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

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

Collaboration between academics, industry groups, and researchers from other National Marine Fisheries Service (NMFS) science centers to assess and reduce sea turtle bycatch in U.S. commercial fisheries in the Northwest Atlantic Ocean has been set up. In 2008, research efforts were focused on Mid-Atlantic bottom trawl fisheries, Mid-Atlantic sea scallop fisheries, and Mid-Atlantic gillnet fisheries. In addition to gear research, analytic work at NEFSC involved estimated bycatch and evaluating mitigation alternatives in trawls and gillnets.

Research on Mitigating Sea Turtle Bycatch in Scallop Dredge Gear

NEFSC continued to work with the Atlantic sea scallop fishing industry on the development and testing of a scallop dredge designed to reduce the likelihood of sea turtle injuries during commercial scalloping operations. The modified dredge was experimentally tested using turtle carcasses and was successful at directing all of the observed interactions up and over the dredge, rather than under the dredge where injury could be caused by the weight of the dredge.

Research on Mitigating Sea Turtle Bycatch in Scallop Trawl Gear

Research to test a larger 132 cm x 114 cm TED with a larger (leatherback) opening for catch retention testing in the scallop trawl fishery is scheduled to commence in June, 2009. The work will build on the 2006 study which used a 132 cm x 81 cm TED and had a catch loss of approximately 8% when compared to a net without a TED.

Research on Mitigating Sea Turtle Bycatch in Bottom Trawl Gear

Collaboration with industry members and academic and NMFS researchers to develop a modified TED design for the summer flounder fishery is ongoing. This TED design and two others were tested in the flume tank at Memorial University, St. John's, Newfoundland, to optimize the configuration of the gear to allow water to pass effectively through the gear even when blockages on the TED and weight in the codend were present. This TED and a subset of the trials of the flume tank testing were further tested in Panama City, Florida for sea turtle exclusion and to compare the results of the flume tank work. Results from this comparison are in the process of being analyzed. Additional testing of flounder trawl nets with larger TEDs and larger (leatherback) opening is scheduled to commence in May, 2009.

Research on Mitigating Marine Mammal Bycatch in Bottom Set Large Mesh Gillnets

The NEFSC recently completed a study investigating the bycatch of marine mammals in large mesh (30.5 cm) bottom set gillnets with different hanging ratios. The bycatch of gillnets hung on the half were compared to gillnets hung on the third. Approximately 80 hauls were conducted, 40 of each treatment, during the months of February to May in an area south of Cape Cod, Massachusetts. The results are in the process of being analyzed.

MIT Sea Grant College Program Centre for Fisheries Engineering Research (CFER), Boston, Massachusetts

Contact: Clifford A. Goudey (cgoudey@mit.edu)

Reduced Impact Scallop Dredge

CFER has developed and tested a new scallop dredge design that eliminates the normal cutting bar, using hydrodynamics to encourage the lifting and capture of scallops. The Hydrodredge design was developed under a $25,000 seed grant from the Northeast Consortium (a funder of cooperative research in New England). The design is based on tow-tank testing of the effectiveness of various hydrodynamic devices at raising scallops off the bottom. A prototype 2.1-m dredge was constructed and observed *in-situ* and evaluated in fishing trials on Stellwagen Bank. Follow-on research has occurred in collaboration with the University of Wales, Bangor and the Dept. of Agriculture, Fisheries and Forestry on the Isle of Man. Testing of the new dredge occurred out of the fishing port of Douglas both in April and August of 2007 in a commercial fishery for the great scallop (*P. maximus*). In these tests the Hydrodredge was less efficient at catching these scallops compared with the toothed Newhaven dredges. However, the new dredge was found to be significantly less damaging to the catch. In addition, the Hydrodredge was found to be especially effective on queenies (*A. opercularis*), a scallop that, like the giant sea scallop (*P. magellanicus*), the New England species for which the design was originally intended, does not burrow in the seabed.

Work in the US has ceased until additional funding for development and further testing can be secured. With CFER cooperation, a 4.6 meter Hydrodredge was built by a fishing company in Canada and tested aboard a commercial trawler over four trips during the summer of 2008. The results revealed equal or better scallop catches compared to the conventional dredge, similar bycatch rates, noticeably reduced drag, and less required maintenance. Two more dredges of similar design are being built by the same company for use during the 2009 fishing season.

Acoustic Control of Trawl Door Altitude

A system designed to eliminate the seabed impacts of trawl doors is under development with support from the MIT Sea Grant College Program and NOAA through the Northeast Consortium. The system will control the height of the trawl door using altitude measurements of a door-mounted sonar. Based on a setting established before the tow, the doors will descend to a specified height and then "terrain follow." The technology will allow the exploitation of low-swimming pelagic species and higher-swimming demersal species. It will operate independently as long as the trawl-wire scope and towing speed are kept within a prescribed range. Therefore, the system will be useful to smaller vessels without the complexity and cost of acoustic-link sensors or an auto-trawl system.

Tank tests of half-scale models were conducted in April 2007 at the St. John's flume tank. Excellent performance of the system was revealed, both on high-aspect midwater doors and low-aspect bottom doors. The acoustic sensor, microprocessor controller, and DC motor actuators have been completed; a pair of NET Systems 2.5 sq. m. Hi-Lift trawl doors will be used to demonstrate the system's functionality in the New England groundfishery during the summer of 2009.

Whale-safe Fishing Gear

CFER continues its efforts to introduce the Whale-Safe Buoy into fixed gear fisheries to reduce the entanglements of marine mammals and endangered species and the loss of gear from buoy-line weak links. By including a stem beneath the buoy with gradual taper and stiffness, the gear is readily shed from whales at low tension in the line, discouraging an encounter from progressing into an entanglement. Release loads are typically less than 10% of the buoy line weak-link requirements under the Atlantic Large Whale Take Reduction Plan. This is not only beneficial to whales, but also reduces gear loss from weak-link failures. Work will continue on this innovative buoy as funding allows.

Energy Efficient, Novel Fishing Systems

CFER has formalized a program to explore opportunities to improve the energy efficiency of commercial fishing through the development of innovative methods and technology. These initiatives range from waste-heat refrigeration, to passive midwater fish traps, to fish attraction and control using light and acoustics, to the recapture of acoustically trained fish released from hatcheries. Work has begun with industry toward the design of an electric hybrid powered fishing vessel. Plans are also in place to implement high-efficiency electric towing thrusters on vessels otherwise designed for efficient passage making. CFER seeks collaborators to broaden the scope of each of these programs.

The University of Massachusetts Dartmouth School for Marine Science and Technology (SMAST), New Bedford, Massachusetts

Contact: Sally Roman (sroman@umassd.edu)

Study fleet net mensuration project

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 an effort level. The project has incorporated technological advances with the use of gear measuring equipment, digital motion compensating scales, and temperature-depth sensors. Gear dimensions have been collected during normal fishing operations with Netmind mensuration equipment during study fleet trips when an SMAST technician is onboard. Sensors are placed on the otter trawl doors, headrope, and the top wings of a net. Data collected can yield more accurate estimates of fishing effort and allow fishermen to view net dimensions in real time to maximize gear performance. Data has been utilized in an exploratory manner to examine for a relationship between total catch and area swept. Analyses of the measurement and catch data indicated that increases in area swept by the trawl gear did not result in similar proportional increases in total catch implying that efficiency was negatively affected. Further uses of the data include assessing habitat impact and investigating links between specific gear types and bycatch. Data collection is planned to continue as the Study Fleet project progresses.

University of New Hampshire

Contact: Pingguo He (pingguo.he@unh.edu)

Species separation in groundfish trawls

A raised footrope haddock trawl was designed and tested at sea. The trawl rigged with the fishing lines 1 m off seabed seemed most suitable for reducing cod catch (by 63%) while maintaining haddock catch (9% reduction), when compared with regular rockhopper groundgear with fishing lines 0.15 m off the seabed. A project testing the rope separator haddock on offshore grounds (Georges Bank) with larger vessel (>90 ft) has been funded with sea trials planned during the fall 2009 and spring 2010. Selected papers presented at the 2007 international haddock symposium held in Portsmouth, NH were published in a special volume in Fisheries Research. [He *et al.* editors. 2008. Haddock Conservation, Harvesting and Management. Fish. Res. 94: 119–206.]

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 very positive results. The fishermen are able to catch more shrimps with markedly less bycatch of finfish species. A shrimp trawl size and species sorting grid experiment is currently being 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.

Reducing seabed impact of trawling

A preliminary project to design and test a wheeled groundgear to reduce seabed impact in the whiting fishery has been completed. An in-depth examination of trawl components and how they impact the seabed was carried out in a flume tank (Chris Glass and Pingguo He). Further work is being planned to improve trawl designs with less seabed impact.

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

Contact: Steve Eayrs (steve@gmri.org), Dan Salerno, Adam Baukus, Nicole Stephens

A contemporary assessment of the bycatch of regulated species and the Nordmore grate in the Northern Shrimp fishery

The mandatory introduction of the Nordmore grate in the Gulf of Maine northern shrimp trawl fishery (*Pandalus borealis*) in 1992 was aimed at reducing bycatch of regulated groundfish species to 5% or less of total catch volume. We conducted a bycatch assessment during the 2008/2009 northern shrimp season to assess the efficacy of the Nordmore grate both spatially and temporally across the fishery. Field sampling for this project occurred from January–March 2009 for a total of 36 sea days and 128 hauls. Sampling occurred aboard four vessels in four different locations between Portsmouth, New Hampshire and Port Clyde, Maine. Preliminary results indicate the average regulated species (RS) bycatch for all boats/locations was 1.6% of total catch weight. Over 75% of 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%, was below 8%. Bycatch in all locations was dominated by American plaice (dab), a red/white hake mix, and winter flounder (blackback). The average RS bycatch for Northern Massachusetts was <1%. At the Boon Island, Maine sampling site, average RS bycatch was 3% in January and <1% in February. The grate was inverted for downward exclusion for 13 tows at this site in January, but there was little difference in bycatch. In Portland, the average RS bycatch remained between 1.3–1.6% for all three months of sampling. Port Clyde consistently had the lowest levels of RS bycatch for the entire sampling period with averages of 0.5% and below. Further analyses will more closely focus on variation in bycatch between study sites and months and the identification of factors affecting the operational performance of the Nordmore grate.

Analysis of Size Selectivity and Bycatch in the Gillnet Fishery for Monkfish

The New England monkfish fishery is the most valuable groundfish fishery in the region, and landings are typically taken using trawls and tie-down gillnets. In the summer of 2008, we compared monkfish and bycatch catch rates using three gillnet mesh sizes (10″, 12″, 14″) with identical hanging ratio, and evaluated the selectivity of monkfish by size and sex. We completed a total of 126 net hauls for each mesh size. Soak duration was 48 hours. In additional we completed 29 twenty-minute tows using a monkfish trawl from the same boat to compare the size composition of monkfish caught in a trawl net and the gillnets. Two tows were completed each day, usually less than 0.5 nm from the gillnet strings.

The 12 inch gillnets had the highest monkfish catch rate per net and the lowest bycatch rate. Conversely, the 10″gillnets had the lowest monkfish catch rate per net and the highest bycatch rate. The major bycatch of the three gillnet gear mesh sizes included spiny dogfish, American lobster, thorny skate and Atlantic cod. A decrease in bycatch of spiny dogfish, American lobster and Atlantic cod was noted as the mesh size increased while the thorny skate bycatch increased with mesh size. Monkfish sizes (length) increased with gillnet mesh size. The trawl gear caught significantly smaller monkfish than any of the three gillnet gear mesh sizes. The average length of trawl caught monkfish was 34.9 cm compared to 61 cm, 71 cm, and 78 cm for the 10 inch, 12 in, and 14 in gillnets respectively, and length-frequency comparison between all gears was significantly different. A final report is in preparation at this time.

An assessment of hanging ratio and mesh orientation on bycatch and twine top selectivity in the general category scallop dredge fishery in New England

Scallop dredges are required to have a netting twine top fitted to upper section of the dredge to allow flounder and other fish to escape. The hanging ratio of netting to dredge rings is not prescribed, but typically ranges from 2:1 to 3:1. We are currently testing three sea scallop dredge twine top configurations in the Elephant Trunk Access Area off Maryland and the Great South Channel Scallop Dredge Exemption Area in southern New England. The goal is to determine whether changes to the twine top hanging ratio or mesh orientation will affect catches of scallops and bycatch. The three treatments that are being tested are a 3:1, 2:1 and 3:1 turned 90° hanging ratio.
The Elephant Trunk Access Area sampling has been completed and the Great South Channel Area sampling will commence in May and July.

Evaluation of the selectivity of four codends in the New England ground fish fishery

The demersal trawl fishermen of Port Clyde, Maine have voluntarily altered their fishing gear to reduce bycatch; however, independent assessment of the efficacy of these modifications has not occurred. In August 2008 we tested a standard trawl codend and three experimental codends to reduce bycatch in the fishing grounds adjacent to Port Clyde. The standard codend was constructed from 6.5 inch diamond mesh netting. The experimental codends included: a 6.5 inch diamond mesh codend with a small chaffing net attached; a 6.5 inch square mesh codend, and; a 7.0 inch square mesh codend. A small mesh cover net was used to encapsulate the codend and retain small fish and other animals that escaped through the codend meshes. The 6.5 inch diamond mesh codend retained 46% of all fish and other animals that entered the trawl. The addition of the chaffing net increased this proportion to 57%, and the 6.5 inch and 7.0 inch square-mesh codends retained 50% and 40% of the catch respectively. The 7.0 inch square-mesh codend retained the lowest proportion of commercially valuable fish (33%) and the 6.5 inch diamond mesh codend with chaffing net retained the highest proportion (44%). Most commercial fish were retained in the cover net, although most were sub-legal (undersized). The proportion of non-commercial catch retained in the square-mesh codends was less than 34%. In contrast, the 6.5 inch diamond mesh codends with and without chaffing net retained 72% and 65% of the non-commercial catch respectively. The 6.5 inch diamond mesh codend retained the lowest proportion of legal sized American plaice (52%) by weight while the 6.5 inch square-mesh retained the highest proportion (82%) With the chaffing net attached, the proportion of legal sized American plaice in the 6.5 inch diamond mesh codend increased to 69%. This codend also retained the highest proportion of sub-legal American plaice (18%). The 7.0 inch square mesh codend retained the lowest proportion of sub-legal American plaice (7%). Overall each codend allowed the escape of at least 43% of fish and other animals that entered the trawl. Compared to the standard codend, fewer sub-legal and more legal-sized American plaice and Grey sole were caught in the square-mesh codends. These codends also retained less bycatch of non-commercial fish and other animals. The use of square mesh codends and removal of the chaffing net are positive steps that can improve the selectivity of demersal trawling.

University of Rhode Island – Rhode Island Sea Grant (URI-RISG), Kingston, Rhode Island

Contact: Laura Skrobe (lskrobe@uri.edu), Kathleen Castro, David Beutel, and Barbara Somers

Use of the Eliminator Trawl with Fishing Vessels in the 250 to 550 HP Range

A study was funded through NMFS to investigate the effects of employing a large mesh faced (top, bottom, wings, and side panels) bottom trawl on reduction of cod and other bycatch from the directed haddock bottom trawl fishery. This work is based upon "Bycatch Reduction in the Directed Haddock Bottom Trawl Fishery" (Beutel *et al.*, 2008 Fish Res. 94:190-198). Two nets are being investigated which are reduced in size compared to the original Eliminator Trawl™ to be used by smaller horsepower vessels. The project is designed to investigate the quantity and catch composition of bycatch, particularly cod and flounders, of the currently regulated trawl net and the experimental nets. To date, sampling is complete for the smallest net size and data analysis is underway. Sampling for the middle size net is in the planning stages.

Fishery Independent Scup Survey of Eight Selected Hard Bottom Areas in Southern New England

This project is entering its sixth year of funding, obtained through the Mid-Atlantic Research Set-Aside (RSA). 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 URI - RISG 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, trawl data collected by the National Marine Fisheries Service (NMFS) and the RIDEM DFW. Additionally, analysis will be conducted on all six years of data.

The Reduction of Butterfish and Scup Bycatch in the Inshore Loligo Squid Fishery

This project was funded through the Southern New England Collaborative Research Initiative and investigated the performance of an experimental trawl on its ability to reduce the catches of butterfish and scup in the *Loligo* squid fishery in Southern New England. Two commercial fishing vessels will be used to conduct the sea sampling in cooperation with URI – RISG. The commercial vessels will conduct side-by-side catch comparison hauls comparing the experimental net to the control net. The project is designed to investigate the quantity and catch composition of bycatch, particularly butterfish and scup, of the trawl nets. Sampling will be conducted in and around Block Island Sound and Rhode Island Sound in the fall 2009 and spring 2010. The experimental net will be the same as the control net except for an escape panel and funnel. Testing of the model net will be conducted in the flume tank at the Marine Institute of Memorial University in Newfoundland in early July. In addition, one field day will be dedicated to testing the location of the funnel before the actual sea sampling.

Development of a Behavioural Assay to Estimate Discard Mortality of Summer and Winter Flounder

Funding was received through RISG to develop and validate a Reflex Action Mortality Predictor (RAMP) and visual marker index for predicting delayed discard mortality of summer and winter flounder. The goals of the project include: (1) Identifying specific behavioural reflex actions and visual markers of summer and winter flounder for use as indicators in a RAMP assay/index and (2) validating the accuracy of the RAMP and visual marker index for predicting delayed mortality of trawl caught flounder. Research began in the fall of 2008. In our initial investigations we developed a RAMP index that appears to predict mortality of trawl caught summer flounder with a relatively high degree of accuracy. In the proposed research we seek to extend these findings in a study with the following objectives: (1) Validate the RAMP index for summer flounder using fish caught on commercial trawlers under a variety of fishing conditions, (2) test the RAMP index for summer flounder captured in a gill net fishery, and (3) develop and validate a RAMP assay for winter flounder. Six behavioural reflexes were chosen for this study after extensive on-board observations of flounder behaviour: “flopping”, mouth opening response, gag reflex, opercular movement, pelvic fin movement, and dorso-ventral righting. Immediately following landing, the RAMP indicators were measured and the fish subsequently transported to a research laboratory and maintained in tanks for 60 days to observe potential delayed mortality, health, and growth. Initial results show a high degree of accuracy in predicting delayed mortality. Codend mesh size, vessel towing speed, length of tow, as well as temperature and deck time can markedly influence the physiological status and ultimately survival of the fish, something the RAMP assay aims to quantify.

Collaborative Project: Sector Based Management - a Win-Win Solution for New England Fisheries

A pilot project for a sector based approach was approved by the State of Rhode Island for the summer flounder (fluke) 2009 fishing season. Eight vessels (7 trawlers and 1 gill netter) will participate in the sector, fishing alongside other federally licensed non-sector vessels. This offers a unique opportunity to compare current fishing practices (Days-at-Sea (DAS) and state mandated daily total allowable catches (TACs)) with a new co-management approach. This study is a collaborative approach between fishermen, scientists, Sea Grant extension, environmentalists, and state and federal managers. This project provides an opportunity for full involvement of all stakeholders in the collection of biological information for management of the NE Region marine resources. The specific information collected will include comparisons between sector and non-sector vessels in rates of discard of summer flounder, discard mortality, trawl designs, monitoring options, and economic and socio/cultural aspects of fishing under different management regimes. These projects will enhance the collection of information for stock assessment of summer flounder (and winter flounder), information for stock rebuilding, and insight into incentives for participation in sector based management.

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 Kraus (New England Aquarium), Patrice McCarron (Maine Lobstermen's Association), Andy Read (Duke University Marine Lab), Rich Ruais (Blue Water Fishermen's Association)

Research and Development of Alternative Fishing Ropes

Mortality from entanglement in fixed gear ropes threatens the survival and recovery of the endangered North Atlantic right whale (*Eubalaena glacialis*), reduced to a population of only some 400 individuals. Through collaboration between fishing gear engineers, whale biologists, and lobster fishermen, the Consortium has developed and is evaluating several potentially "whale-safe" ropes in the Gulf of Maine, including ropes that have glow properties underwater which may increase their visual detection by whales, and a weaker hauling rope that can part easier under the force exerted on it by an entangled whale. The Consortium is also interested in testing acoustic release technologies that are practical and affordable for the fishing industry. Dr. Ken Baldwin at UNH recently completed a project simulating encounters between various fishing lines and an anatomically accurate model of a right whale flipper. The full report from this project will be available on the Consortium's website in June (http://www.neaq.org/conservation_and_research/projects/fisheries_bycatch_aquaculture/bycatch/consortium_for_wildlife_bycatch_reduction/index.php).

Research and Development of Approaches to Reduce Depredation by Cetaceans and Other Species

The Consortium is supporting Dr. Andy Read's study of interactions between longline fishing operations and pilot whales in the Cape Hatteras Special Research Area (CHSRA). Pilot whale mortality results from entanglement in fishing gear which is a consequence of depredation of target catch. The principal research questions that are the focus of this study include a determination of the species involved, local use patterns of pilot whales within the CHSRA, and both how and when whales interact with longline gear. Ultimately, the objective of this project is to use better understanding of whale-longline interactions in identifying effective bycatch reduction methods. The results to date suggest that it is only the short-finned pilot whale (*Globicephala macrorhynchus*) that is interacting with gear, that some whales likely reside in the CHSRA, and that interactions occur at all stages of fishing operations. Future plans include deploying more depth and sound detectors to characterize whale behaviour, conducting a stable isotope analysis, and studying whale social structure.

Global Bycatch Reduction Techniques Database (www.bycatch.org)

The Consortium has established a searchable on-line 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 based in different countries. Recently, new references were uploaded by the ICES Study Group for Bycatch of Protected Species

Marine Conservation Engineering Program, New England Aquarium, 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. The first field trial will begin in September of 2009 in the artisanal croaker fishery off Argentina.

Virginia Institute for Marine Science (VIMS), Gloucester Point, Virginia

Contact: Chris Hager (hager@vims.edu)

Fishing Gear Technology Expert Work Group

A US Atlantic Coast group of gear technologists produced an analysis for the Atlantic States Marine Fisheries Commission (ASMFC) identifying and ranking jurisdictional fisheries with notable levels of catch of non-target organisms. The group identified and evaluated studies of fishing gear selectivity, bycatch reduction, gear effects on habitat, and impacts of a single gear used in multispecies fisheries (ecosystem planning); developed a comprehensive report of gear work along the coast; evaluated the work to see if it is ready to be implemented in the management process, developed research recommendations, and determined the transferability of completed research to other species and geographical areas. This included identifying relevant studies from outside the Atlantic Coast and evaluating their findings for possible application to ASMFC species. Based on a prioritization matrix of ASMFC managed fisheries, the group identified ten fisheries and comprehensively investigated known research for those fisheries.

NOAA Fisheries, Southeast Fisheries Science Center, Mississippi Laboratories, Engineering and Harvesting Branch

Contact: Daniel G. Foster (Daniel.G.Foster@noaa.gov)

Research was conducted in 2008 to evaluate the efficacy of a new 16/0 "weak" circle hook design in reducing the bycatch of bluefin tuna in the Gulf of Mexico yellowfin tuna fishery. From 5/09/08 to 7/02/08, two commercial vessels completed 72 pelagic longline sets. Experimental hooks constructed of 3.65 mm wire and standard 16/0 circle hooks (4.0 mm wire) were alternated on the longline with a total of 36,766 hooks set. A total of five bluefin tuna were caught during the experiment. Four were caught on the control hook with one coming from the experimental gear (75% reduction). A total of 652 yellowfin tuna were caught, with the experimental hook having a 6% higher catch rate than the standard hook. The differences in the standard and experimental hooks for bluefin and yellowfin catch rates were not significantly different. However, the failure to detect a significant difference in bluefin catch was likely due to the small sample size. Additional trials are being conducted in 2009 in order to fully evaluate the potential of the new hook design to reduce the incidental take of bluefin tuna on pelagic longlines in the Gulf of Mexico yellowfin tuna fishery.

Oregon Department of Fish and Wildlife, Marine Resources Program, Newport, Oregon

Reducing bycatch of yelloweye rockfish in hook-and-line groundfish fisheries: evaluation of the effect of increased bait height above bottom on the catch of demersal rockfishes (*Sebastes*)

We completed a study of how increasing the height of angled baits above the bottom using long leaders (4.6 m) inserted between the lowermost bait and the terminal weight (long-leader gear) altered the species and size composition of the recreational catch off the Oregon coast. A report summarizing this work is available at http://www.dfw.state.or.us/MRP/publications/. An exempted fishing permit (EFP) under the auspices of the Pacific Fishery Management Council is being conducted in 2009 by the Recreational Fishing Alliance to test this gear in an offshore recreational target fishery for yellowtail rockfish.

Contact: Bob Hannah (bob.w.hannah@state.or.us), Troy Buell

Evaluating the effect of bar orientation in a rigid-grate BRD in the ocean shrimp (*Pandalus jordani*) trawl fishery

We tested two identical rigid-grate BRDs in the Oregon shrimp trawl fishery that varied only in how the bars were oriented, either vertically or horizontally. Tests were conducted simultaneously using the two matched nets of a double-rigged shrimp trawler and also utilized underwater video. Bar orientation did not alter the composition of fish retained by the nets, suggesting that the sorting process at a rigid-grate BRD is a physical sorting process for smaller species, probably with behavioural effects being less important, at least for the species present in these tests. The fish encountered included several juvenile rockfish and small-bodied flatfish, as well as juvenile Pacific hake. Underwater video showed a definite behavioural component for larger fish when interacting with the grid and also showed that a horizontal bar orientation increased shrimp escapement from the trawl due to a build up of shrimp at the two- and ten-o'clock positions on the grate with horizontally-oriented bars.

Contact: Bob Hannah (bob.w.hannah@state.or.us), Steve Jones

ROV survey of soft-bottom habitats affected by shrimp trawling

We completed an ROV survey of mud-bottom habitats in four areas near Nehalem Bank to study the impacts of shrimp trawls on macro-invertebrate populations. The four study sites have different trawling histories and two of the sites are within the Nehalem Bank no-trawl zone established in 2006. The study showed some impacts on benthic macro invertebrates from chronic trawling, including reductions in density of sea whips, orange sea pens, sea cucumbers, squat lobsters and corals in the more heavily trawled areas. Seafloor complexity was higher in the heavily trawled areas due to higher densities of hagfish burrows, the dominant structural feature in these flat mud habitats, raising the possibility that hagfish populations may have been enhanced by fish discards.

Contact: Bob Hannah (bob.w.hannah@state.or.us), Steve Jones, William Miller, Jayme Knight

NOAA Fisheries, Alaska Fisheries Science Center, Fisheries Behavioral Ecology Program, Newport, Oregon

Using behavioural indices to predict freeze-related discard mortality in Alaskan crab species

Millions of crabs are sorted and discarded each year in Alaskan fisheries for Tanner crab (*Chionoecetes bairdi*) and snow crab (*C. opilio*). Discards are primarily males smaller than market size, and these are frequently exposed to air temperatures below freezing during winter fishing seasons. A small group of studies has shown that low temperature and wind chill kills crabs, but conditions at sea, exposures, and handling methods vary widely throughout the fishing season and among different vessels, and mortalities are difficult to estimate. A shipboard laboratory experiment was conducted to determine whether simple behavioural observations can be used as indices of crab condition over the range of likely low-temperature field exposures. Crabs were systematically subjected to -10 and -20 °C in seven different exposures standardized on the basis of degree-hours (h). They were then tested for six different reflex actions as well as righting behaviour and held for 9 days to track mortality. Crabs lost limbs, showed reflex impairment, and died in direct proportion to increases in cold exposure. Righting behaviour was a poor predictor of mortality in individual crabs, while the best predictor was reflex impairment scored as the sum of reflex actions that were lost (range = 0 to 6). This composite index could be measured quickly and easily in hand. Logistic regression revealed that the relationship between reflex impairment and mortality correctly predicted 80.0% of the mortality and survival for *C. bairdi*, and 79.4% for *C. opilio*. These relationships provide substantial improvements over earlier approaches to mortality estimation and were independent of crab size and exposure temperature.

Contact: Allan W. Stoner (al.stoner@noaa.gov)

NOAA Fisheries, Alaska Fisheries Science Center, Resource Assessment and Conservation Engineering Division, Seattle, Washington

Projects planned for 2009–2010

Selectivity of Midwater Trawls used in Acoustic Surveys of Walleye Pollock behaviour in midwater trawls will be observed by jointly deploying a dual-frequency identification sonar (DIDSON) to track fish and still digital stereo-cameras to identify fish species and provide length measurements. Observations will be used to characterize length-dependent behaviours that contribute to selectivity of the gear.

Contact: Kresimir Williams (kresimir.williams@noaa.gov)

Assessment of rockfish in untrawlable areas

Rockfish are difficult to assess using bottom trawls due to their propensity to aggregate in rocky high-relief areas. The purpose of this study is to improve assessments of rockfish abundance using a combination of vessel mounted acoustics, stereo-optic cameras and a semi-pelagic trawl in areas currently un-surveyable by bottom trawls.

Contact: Chris Rooper (chris.rooper@noaa.gov)

Modelling the effects of improved estimates of survey selectivity and changes in net design for snow crab

A study is planned to experimentally estimate the catchability coefficient (q) and other selectivity parameters of a survey bottom trawl for snow crab, then through a series of model fitting experiments, determine if there is an improvement in the estimates of TAC or OFL using the current crab management model under three scenarios: 1) allowing q to be unconstrained and estimated along with the other model parameters, 2) using the experimentally-derived estimates of q as priors in the model fitting process, 3) setting q=1, as though using a survey gear that is not size selective over the size range of importance to management.

Contact: David Somerton (david.somerton@noaa.gov)

16 Report from FAO

Frank Chopin presented an overview of FAO, its relationship with other UN agencies and how it operates as the secretariat to the Committee on Fisheries (COFI). He then presented a summary of actions arising from COFI 28 in the area of fishing technology and fish behaviour and of potential interest to WGFTFB members. These included inter alia; publication of the best practices technical guidelines for the implementation of the International Plan of Action for Reducing the Incidental Catch of Seabirds in Longline Fisheries, the development of guidelines on best practices for safety at sea, continued collaboration with the International Maritime Organization (IMO) and the International Labour Organization (ILO) in the areas of safety at sea, work on fishing vessels and health standards, assistance for the implementation of the International Guidelines with regard to the management of fisheries resources exploited through deep-sea fishing as well as identification and protection of vulnerable marine ecosystems, the development of a comprehensive Global Record of Fishing Vessels, Refrigerated Transport Vessels and Supply Vessels, the development of International Guidelines on Bycatch Management and Reduction of Discards and the need to establish a specific global programme dedicated to small-scale fisheries. Frank then provided a brief overview of the re-organization of the structure of the

Fisheries Department in accordance with implementation of the Immediate Plan of Action before addressing ongoing areas of collaboration between WGFTFB and the FAO fishing technology service. He noted the significant contributions made by Messrs Ferro, Bundit, Thiele and Eayrs on the issues of collaboration.

Promotion on the Use of Circle Hooks in Southeast Asia

Contact: Bundit Chokesanguan, Somboon Siriraksophon, Training Department, Southeast Asian Fisheries Development Center (SEAFDEC/TD), Phrasamut chedi, Samutprakan, Thailand (bundit@seafdec.org)

SEAFDEC Training Department, as a technical agency in the promotion of responsible fishing technologies and practices in the Southeast Asian region, has studied the mitigation of fisheries-sea turtle interactions through experiments on the efficiency of circle hooks in comparison with J hooks in the longline fishery in Southeast Asian waters. The study objectives are to investigate the efficiency circle hooks in comparison with J hooks, the hooking positions between two different types of hook and the impact of longline fishery on mortality of sea turtles caught incidentally in waters of the Southeast Asian region.

Six experiments have been conducted in the Andaman Sea, waters of Brunei Darussalam, waters of Myanmar, waters of Thailand, the Celebes Sea of the Philippines and the Indian Ocean. The results of the experiments found that the efficiency of catch was not different between these hooks but that shark and other non valued bycatch was reduced by 20% by using circle hooks compared with J hooks.

As for the position of hooking of circle hooks, 85% of fish were caught in the mouth and 4% in the digestive system compared to 25% of fish caught in the digestive system using J hooks.

In order to reduce catch of sea turtles in longlines, the promotion on the use of circle hooks was conducted through training/workshops in the Philippines, Indonesia, Thailand, Vietnam and Malaysia in 2006/2007. The information packages were also produced and disseminated in the region for that purpose.

SEAFDEC in cooperation with Southeast Asian countries will continue to promote this in the region under the Project on Responsible Fisheries Technologies and Practice with the support of the Japanese Trust Fund and other organizations in other regions.

The Use of Turtle Excluder Devices in Southeast Asia

Since 1996 SEAFDEC Training Department has conducted numerous trials and demonstrations on the release of sea turtles from trawl fishing through the use of TEDs in the Southeast Asian waters including the national waters off Thailand, Malaysia, Indonesia, Brunei and the Philippines. The results were then disseminated to fishermen, since shrimp trawling supports a large number of fishermen in the region.

In order to continue the successful promotion on the use of TEDs in the region, an evaluation and assessment on the use of TEDs was conducted through questionnaires addressed to fishermen and interviews in countries that TEDs have been introduced. The assessment and evaluation were conducted to establish the attitude of fishermen and the people who were involved in the process of the applications and implementation on the use of TEDs.

SEAFDEC in cooperation with Southeast Asian Countries will continue to promote the use of TEDs in Southeast Asia and other regions under the Project on Responsible

Fisheries, Technologies and practices with the support of the Japanese Trust Fund and the funds provided by GEF/UNEP/FAO to support the activities which are part of the Reduction of Environmental Impact from Tropical Shrimp Trawling Project Phase I and II.

17 New Business

17.1 Date and Venue for 2010 WGFTFB Meeting

The **ICES-FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chair: Dominic Rihan, Ireland) will meet in [VENUE] on [DATE] May 2009.

The proposed ToRs for 2010 are given in Annex 4 along with proposals for two WGFTFB Workshops as detailed in Annex 5.

17.2 Proposals for 2010/2011 ASC – Theme Sessions

17.2.1 Elasmobranch Fisheries: Developments in stock assessment, technical mitigation and management measures

Conveners: Dominic Rihan (BIM, Ireland); Jim Ellis (Cefas, UK); Henk Heessen (IMARES, The Netherlands)

Elasmobranchs (sharks, skates and rays) are taken in a range of targeted and mixed commercial fisheries, and are also of interest to recreational fisheries and wildlife conservation groups. The large size of elasmobranchs and their aggregating nature makes them susceptible to capture in many fisheries from an early age. They are also biologically vulnerable to fishing impacts, given that their life history strategy involves a late age at maturity, slow growth and low fecundity. Declines and regional extirpations have been documented for a range of elasmobranch populations and there has been an increased concern over the status of several species/stocks in recent years. In 1999, the FAO published its International Plan of Action for Sharks (IPOA–Sharks), giving guidelines for data collection and management measures, and it was recommended that shark action plans be implemented at a national level.

Although elasmobranchs are at a high risk of capture in fishing operations, they have to date received limited attention in terms of bycatch mitigation in comparison to other charismatic megafauna (e.g. cetaceans and sea turtles). Nevertheless, in the course of research into mitigation devices for release of marine mammals, options to reduce elasmobranch bycatch have been found (e.g. in Mauritanian pelagic fisheries). Other possible mitigation devices aimed specifically at reducing their bycatch have been suggested but not fully developed.

In order to address many of the current issues in elasmobranch fisheries management, it is proposed to hold a theme session at the ICES ASC 2010. This theme session aims to bring together recent studies on elasmobranch fisheries and talks on the following subjects are encouraged:

- Development of stock assessment methods.
- Utility of fishery-independent surveys for examining long-term trends in spatial extent and relative abundance.
- Reconciling fisheries stock assessment and conservation assessment methods.

- Development of Ecological Risk Assessments (ERA) and management plans for species-complexes (e.g. “deep-water sharks”, “demersal skates”, “pelagic sharks”).
- Studies on the efficacy of potential management measures.
- Research with technical mitigation measures used directly or indirectly to reduce elasmobranch bycatch.
- Discard survival of elasmobranchs taken by commercial fishing gears.
- Size restrictions for elasmobranch fisheries: should managers protect the young (e.g. with a minimum landing size, MLS) and/or mature females (e.g. with a maximum landing length, MLL).
- Spatial management for ecologically important elasmobranch habitats.
- Management of highly migratory shark stocks.
- The implementation of National Plans of Actions for Sharks and their outcomes.

17.2.2 Alternative Fishing Gears

Conveners: Bjarti Thomson, Faroe Islands and Michael Pol, US

Justification

Increases in energy costs and greater awareness of environmental impacts have led to a greater interest in innovative, low energy, low impact fishing gears. Recent investigations of fish pots have highlighted the need to increase the efficiency of these gears to become a viable alternative. It has been proposed that a behavioural model of fish attraction, capture, and retention can be used to help understand the static gear capture process. Several ICES and non-ICES nations have prioritized the investigation and improvement of static gears both for commercial and survey purposes. Drawing on a model of attraction, capture and retention, this theme session has the objective to assist in the development of low energy, low impact fishing gears by gathering together new research on fish behaviour in relation to static gears.

Papers will be invited on farfield attraction (e.g. chemosensory reception), nearfield stimuli (e.g. vision and mechanosensory reception), and gear modifications that improve catch and retention of fish in static gears.

17.3 ICES and other symposia

An ICES Symposium on the Collection and Interpretation of Fishery Dependent Data will be held on 23–24 August 2010, in Galway, Ireland. Conveners: N. Graham (Ireland), K. Nedreaas (Norway), and W. Karp (USA). More information can be found at www.fisherydependentdata.com.

The Dutch Ministry of Agriculture, Nature and Food Quality (LNV), will host a 2 day conference for fishermen and policy makers on fisheries innovations on 8–9 October 2009 in Amsterdam. The aim of this conference is an exchange of ideas and challenges of individual countries developing their fisheries innovation agendas and how fishermen innovate their fisheries. From this, we aim to identify promising approaches, novel ideas, as well as more synergy between initiatives. Furthermore information will be shared about a European Fisheries Technology Platform in creation (EFTP). More information can be found at www.fisheriesinnovationplatform.com.

A conference entitled Fish Sampling with Active Methods (FSAM) will be held from 8 to 11 September 2010 in the Institute of Hydrobiology, Ceske Budejovice, Czech republic. More details are available at www.fsam2010.wz.cz.

17.4 Any Other Business

17.4.1 Database of global bycatch reduction techniques

The Consortium for Wildlife Bycatch Reduction has established a searchable on-line database of global bycatch reduction techniques (www.bycatch.org). The database includes citations for bycatch studies with summaries of their main findings. The by-catch 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 based in different countries, and are encouraged by WGFTFB members, including "grey" literature.

17.4.2 Eulogy to Professor Fridman

WGFTFB wish to put on record the contribution made to fishing technology research by Professor Alexander Fridman who passed away in 2007. A eulogy to Professor Fridman written by Steve Eayrs, Henry Milliken, Menakhem Ben Yami and Joe DeAlteris is included in Annex 9.

Annex 1: List of participants

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Annex 2: Agenda

18 May
08:30 – 09:00 Registration
09:00 – 09:15 Opening Address
09:15 – 09:30 Housekeeping Issues & Meeting Arrangements (Chair)
09:30 – 16:00 JFTAB

19 May
09:00 – 09:10 Opening Address
09:10 – 9:30 New ICES Business & Requests (Chair)
09:30 – 10:30 FAO Briefing (Frank Chopin)
10:30 – 11:00 Coffee Break
11:00 – 11:05 Introduction to Open Session (Chair)
11:05 – 11:25 Investigation of the pair-gear method in selectivity studies – Manu Sistagu
11:25 – 11:45 Estimation of distribution density of snow crab and net efficiency of survey trawls using a deep-sea underwater video system on a towed sledge- Dr Heui Chun An
11:45 – 12:05 How three different hauling techniques influence retention proportions of fish in the Norwegian mechanized longline fisheries – Lasse Rindahl
12:05 – 12:25 Fleet spatial dynamics in Portuguese coastal trawlers – Aida Campos
12:30 – 14:00 Lunch Break
14:00 – 14:20 Update on Electric Beam trawl work (Bob van Marlen)
14:20 – 14:40 Update on Gear Classification (Dick Ferro)
14:40 – 1450 ToR a Advice to Assessment WGs (Chair)
14:50 – 15:10 ToR b Seine Net Fisheries
15:10 – 15:40 ToR c on Discards
15:40 – 16:00 Coffee Break
16:00 – 16:20 ToR c on Discards (continued)
16:20 – 17:00 ToR d on Mediterranean Fisheries
17:00 – 17:15 NAFO request on cod separation
17:15 – 17:30 WGECO ToR on gear efficacy

20 May
09:00 – 18:00 Topic Group Meetings
Coffee breaks @ 10:30- 11:00 & 15:40-1600
Lunch break 12:30-14:00

21 May
09:00 – 18:00 Topic Group Meetings

22 May
09:00 – 10:30 Topic Group Meetings
10:30 – 11:00 Coffee Break
11:15 – 11:30 Presentation of report, conclusions & recommendations on Fisheries Advice
11:30 – 12:00 Presentation of report, conclusions & recommendations on Seine Net Fisheries
12:00 – 12:30 Presentation of report, conclusions & recommendations on Discards
12:30 – 13:00 Presentation of report, conclusions & recommendations on Mediterranean

13:00 – 14:00 Lunch Break
14:00 – 14:25 Presentation of results from NAFO request on cod separation
14:25 – 14:50 Presentations and results from WGECO ToR on gear efficacy
14:50 – 15:00 Report from SGPOT (B. Thomson)
15:15 – 15:40 ToRs for 2010 (chair)
15:40 – 16:00 Coffee Break
16:00 – 16:10 Suggestions for ASC theme session topics 2010 (chair)
16:10 – 16:20 Date and venue for WGFTFB 2010 meeting (chair)
16:20 – 16:30 AOB and concluding remarks (chair)

Annex 3:Recommendations

The following table summarises the main recommendations arising from the WGFTFB and identifies suggested responsibilities for action.

RECOMMENDATION	FOR FOLLOW UP BY:
1. WGFTFB recommends a joint ToR be drawn up with WGECO to further test the methodology for assessing the efficacy of gear based technical measures.	WGFTFB and WGECO
2. WGFTFB will continue to collate fisheries related information on an annual basis subject to further revision of the questionnaire used over the last number of years and better quantification of the information where possible.	ACOM, WGCHAIRS.GFCM Asssessment chairs to note
3. WGFTFB recommend that a timetable for provision of this fisheries information to the Assessment Working Groups be drawn up that better reflects the timing of the individual working groups. WGFTFB further recommend that ACOM consider whether this information would be better collated at the Benchmark Workshops.	ACOM, WGCHAIRS.GFCM Asssessment chairs to note
4. WGFTFB will continue to provide fisheries information to GFCM in the Mediterranean and recommend this be extended to include non-EU and non-ICES affilate countries where possible.	FAO-GFCM
5. WGFTFB recommend a comprehensive review be carried out to substantiate the environmental friendliness of Danish seining including ecological impact of seining on seabed habitat and discarding levels in seine net fisheries.	SCICOM; WGECO to note
6. WGFTFB recommend the results of selectivity experiments with seine net gear be reviewed and the methodology for measuring the selectivity of seine nets, which has proven problematically in the past, be assessed.	SCICOM
7. WGFTFB recommends that the factors that influence fishermen into switching between seining & other fishing methods and in particular pair seining or trawling be described.	SCICOM
8. WGFTFB recommend identifying from a technical perspective that Article 9 of Regulation 1967/2006 need to be amended. In the case of Annex II it is recommended Mediterranean workshops to address technical specifications limiting the maximum dimension of trawl nets along with the maximum number of nets in multi-rig trawls are required.	FAO-GFCM & European Commission DGMARE
9. WGFTFB recommend that investigating the survival of fish being discarded and escaping from fishing gears in the Mediterranean should be highlighted as a research priority for all ICES member states.	FAO-GFCM; WGQAF to note.
10. WGFTFB recommends a workshop should be held to develop methods for investigating the escape and discard mortality of key species in the Mediterranean. The workshop would bring together essential areas of expertise, including: fisheries biologists; gear technologists and researchers specialising in escape mortality experiments (both lab & field based).	FAO-GFCM; WGQAF to note.
11. WGFTFB recommend that WGQAF should be requested to coordinate research activities in the area of fish survival research and report progress to relevant ICES EGs.	WGQAF
12. WGFTFB recommend that the effect on selectivity of the use of strengthening bag in Mediterranean fisheries should be investigated. In addition further research should be carried out on the impact of multi-rig trawl and based on a precautionary	FAO-GFCM; European Commission DGMARE to note

approach some restrictions should be considered (i.e. closed areas or seasons).	
13. WGFTFB recommend that the biological, ecological, economical/social aspects of the 50 mm diamond mesh compared to 40 mm square mesh in multi-species fisheries are not fully understood and should be investigated.	FAO-GFCM; European Commission DGMARE to note

Annex 4: WGFTFB terms of reference for the next meeting

The ICES-**FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chair: Dominic Rihan, Ireland) will meet in VENUE [to be determined] on DATE [to be determined] 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.

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: TBC

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 fishermen 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 fishermen and scientists in the process of collaboration and identify conditions enabling rapid uptake of new technology, without the risk of introducing new adverse ecosystem effects.

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

WGFTFB anticipates generation of a joint ToR with WGECO and also possible ToRs from WGQAF.

WGFTFB will report by DATE [to be determined] to the attention of the SCICOM.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. 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 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)** 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 tends to be of much lighter construction and as there are no trawl doors or warps has 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 the early 1990s, in countries such as Scotland and Ireland the number of vessels seining declined as vessels switched to twin-rig trawling, targeting species such as monkfish and *nephrops,* taking advantage of relatively low fuel prices. In recent years, however, as fuel prices have steadily increased attention once again has shifted to this method and 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 a field 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 fishermen globally. For instance in Scotland and Ireland there is evidence of high discarding and high grading as seine netters aim to maximise 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.

	Term of Reference c) Gear monitoring equipment has been used by gear technologists for many years to monitor critical parameters during gear experiments and also during stock assessment surveys. The number of available systems and equipment has grown in recent years with more sophisticated sensors to measure ground contact, net geometry and angle of attacks of doors and grids being developed. The choice of which system is used by gear technologists is largely governed by compatibility with existing equipment but also cost. There are, however, a number of issues associated with these systems in terms of a lack of means of verifying accuracy of the systems used, filtering of error data; manipulation of data collected; calibration with other systems; and reliability and durability of sensors and systems that need to be addressed in consulatation with manufacturers. In addition there are other parameters that would be useful to measure cannot be with the current sensors available. **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 sea bed 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 fishermen and equipment manfacturers. The trend is more and more to directly finance the industry in such endeavours, 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 oter and beam trawls, gear replacement (e.g. alterntaive gears) aimed at reducing energy conusmption, bycatch and/or seabed imapct.
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 50-70 members and guests.
Secretariat facilities:	None.
Financial:	None required. Having overlaps with other meetings of expert groups of FTC increases efficiency and reduces travel costs.
Linkages to advisory committees:	The questions of bycatch reduction, fisheries information and survey 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 Fisheries, WG on Fishery Systems, WG on International Bottom Trawl Surveys, Baltic Committee, Marine Habitat Committee, Resource Management Committee and Living Resources Committee and the Assessment Working Groups.
Linkages to other organizations:	The work of this group is closely aligned with similar work in FAO and also the EU Regional Advisory Councils.

Annex 5:Draft resolution for Workshops

It is recommended that a Workshop (WKGILLMAN) of the ICES–FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] be held in Denmark on DATE [to be determined] (Co-Chairs: Andy Revill (CEFAS, UK) and Rene Holst (DTU-Aqua, Denmark)) to address the following ToRs:

a) Update the statistical methods in the original gillnet selectivity manual.

b) Update the existing text including the development of case studies and the documenting of relevant experiments and analysis carried out as well as identifying graphs and diagrams needed.

c) Identify the boundaries and applicability of the manual need to be detailed i.e. the methods should not be used for species where the selectivity is not well defined (fish with spikes).

d) Produce a final draft for peer review prior to publication.

WKGILLMAN will report by DATE [to be determined] for the attention of the SCICOM.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. 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) Term of Reference a) The ICES Static Gear manual has a history extending back to 1988 when it was first suggested to formulate it. The current draft 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 is important that this manual is now finished. 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 timeframe 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 has not been possible as a number of issues still need to be resolved and therefore a workshop to complete the susbstantive work required to complete the manul seesm the most appropraite form of action.
Resource requirements:	The research programmes which provide the main input to this workshop 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 Wokshop will be attended by some 8-15 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:	There is a very close working relationship with all the groups of the Fisheries Technology Committee.

Linkages to other organizations:	This Workshop is closely aligned with the work of FAO.

Draft resolution for a Workshop

It is recommended that a Workshop (WKPULSE) of the **ICES–FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] be held in IMARES, Netherlands on DATE [to be determined] November 2009 (Chair: Bob van Marlen, IMARES, Netherlands) to address the following ToRs:

a) to review the *in situ* and tank experiments conducted following the request for additional information mentioned in the ICES Advice of 2006 on the electric pulse beam trawl.

b) to review data on the measurement of field strength and pulse characteristics used in the pulse trawl system.

WKPULSE will report by DATE to the attention of the SCICOM.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the effectiveness of technical measures to change size selectivity and fishing mortality rates. 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) Term of Reference a) The use of electricity in fishing is banned Regulation EU No. 850/98. To address ecosystem effects of conventional beam trawling a system using electric pulses has been developed in The Netherlands and is currently being used on a small number of commercial fishing vessels. 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.
Resource requirements:	The research programmes which provide the main input to this workshop 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 Wokshop will be attended by some 8-15 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:	There is a very close working relationship with all the groups of the Fisheries Technology Committee and also the Working Group on the Ecosystem Effects of Fishing (WEGECO).
Linkages to other organizations:	This workshop is of particular interest to the European Commission DGMARE.

Annex 6: WGECO Joint ToR

ToR b) "Using two existing fishing gear types, describe the significant adverse impacts of those gears for the ICES area, using the methodology developed by WGECO in 2008. Highlight issues that are specific to geographic areas and those that are generic to the gear. Based on this process recommend any modifications to the methodology required to make it operational."

Introduction

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 which identified the significant adverse impacts (FAO 2008) of particular fishing gears that should be considered in experiment planning for developing mitigation measures. Throughout this report "significant adverse impacts" is abbreviated as SAI, and "No significant adverse impacts" is abbreviated as NSAI.

It was, however, identified that in order to develop the methodology further and make it operational it required trialling for existing gears. It was also identified that the terminology used for the criteria that defined significant adverse impact would need further consideration as for some aspects of the ecosystem this terminology is poorly defined (see terminology work in ToR a). In addition, the grouping of ecosystem components within assessment categories was revisited.

The objective of ToR b was to work through an assessment of the significant adverse impacts of two specific fishing gears and using the experience 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. These two gears were selected as they represented one gear (beam trawls) that is well studied with an accepted high impact on habitats and benthos, and a second gear (gillnets) that has documented marine mammal and seabird bycatch impacts but is recognised as being environmentally benign in most other respects.

Vulnerability of species to particular fisheries is dependent partly on the likelihood of them suffering any mortality due to the fishery, and also on their sensitivity to the fishery.

- Mortality should be interpreted as any mortality resulting from the fishery, including both mortality sustained in the catch and in the path of the gear (e.g. in the towpath of the gear on the seafloor, or after passing through the gear). This is as defined in 2008.
- Sensitivity is itself a function of the resistance of the species to the fishery (its' gear and behaviour), and the resilience of the species to raised levels of mortality (ability to recover) (Bax and Williams, 2001; Zacharias and Gregr, 2005).

There is much literature describing life history and ecological characteristics that are associated with high vulnerability to fisheries and these sources should be consulted by experts in this field when applying this methodology.

The assessment was carried out on four ecosystem component categories:

- 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.

Species "previously identified" refers to species listed in accepted fora such as IUCN or the OSPAR list. If species included in these lists are impacted then the impact of the fishing gear should be classified as SAI. We have also taken the approach that when a species or habitat is listed as at risk of extirpation or complete loss, ANY mortality or damage would represent SAI. It should be noted that these lists should not be over relied on as they are essentially "works in progress" and merely because a species or group of species does not appear on these lists does not necessarily mean they are not Significantly Adversely Impacted.

Generic impacts of two fishing gear types

The generic impacts of the selected fishing gear types are highlighted using the categories of ecosystem components from the proposed framework (ICES, 2008b). WGECO have reviewed the generic ecosystem impacts of various fishing gears in a number of previous reports in particular see ICES 2006. However the WG felt it necessary to summarise these here because the request originated from WGFTFB who may not have considered all this information.

Beam trawl fisheries

Commercial fish species

Beam trawl fisheries are a mixed species fisheries. Species selectivity is rather low (e.g. Van Marlen, 2003), as is size selectivity for several species, plaice (*Pleuronectes platessa*) in particular (Catchpole *et al.*, 2008). Discarding of commercial fish species can therefore be high for the target species such as plaice, but also for other commercial species (van Helmond and van Overzee, 2008). Another major issue is discarding of over quota species such as cod (*Gadus morhua*). Given the high discard mortality for sole (*Solea solea*) and plaice (Van Beek *et al.*, 1990) discarding of commercial fish is a major issue. No assessments have been found on other sources of mortality. Tow path mortality is expected to be negligible for most fish species, escape mortality can, however, be of concern. Next to direct effects, there are indirect consequences such as improved feedings conditions for flatfish (Rijnsdorp and Vingerhoed, 2001).

Listed species including fish, cephalopods and benthos

A proper assessment requires an authoritative collation of all previously listed species within the three species groups. It was not possible to collate such a list during the WG meeting but some indications of potential generic impacts are described below. An approach was made to the construction of a coherent list as part of the work for ToR E of the WGECO report (see chapter 8.5.5.)

Beam trawl fisheries are known to cause high species mortality for some benthic invertebrates, mostly attributable to mortality in the tow path. Direct mortalities range from about 5 up to 40% of the initial densities for a number of gastropods, starfishes, small and medium-sized crustaceans and annelid worms. For bivalve species, mortalities were found from about 20 up to 65%. For the Dutch sector, annual fishing mortality in invertebrate megafaunal populations ranged from 5 up to 39%, with half of the species showing values of more than 20% (Bergman and van Santbrink, 2000).

The catch (numbers) per unit of effort for non-commercial fish species is low (van Helmond and van Overzee, 2008). However, a large number of species are affected and the survival rates are expected to be low, implying a high impact.

Cephalopods can be a by-caught product of flatfish directed beam trawl fisheries (e.g. van Helmond and van Overzee, 2008) and can be discarded at high rates, e.g. Enever *et al.* (2007). There are also records of cephalopods being the target commercial species in winter. Fishing mortalities indicate a rather stable exploitation pattern for cuttlefish in the English Channel (Royer *et al.*, 2006). Discard issues have not been estimated for this fishery. Other sources and levels of "unaccounted" direct mortality are not anticipated.

According to these known impacts, it is expected that beam trawl fisheries could potentially impact listed species, whether benthic invertebrates, non-commercial fish or cephalopods, to a similar degree. The extent of spatial overlap between the distribution of listed species and fishing effort distribution is, however, an important factor that would be required to enable expert judgement of the impact level.

Marine mammals, marine reptiles and seabirds

There are no reported by-catches of marine mammals and marine reptiles. The direct effects of by-caught seabirds in beam trawl fisheries are likely to be negligible (Courtens and Stienen, 2008). Discarding from beam trawl fisheries provides an important food sources for several seabird species and has important implications at the population level, depending on the area (Camphuysen and Garthe, 2000; Tasker *et al.*, 2000).

Pelagic and benthic habitats and assemblages

Beam trawl fisheries can change the physical 3D-structure of the seabed, e.g. by flattening sediment structures, removing large physical structures e.g. boulders and oyster beds, sediment compression and penetration (Paschen *et al.*, 1999; Fonteyne, 2000; Lindeboom & de Groot, 1998) and therefore reduce habitat complexity (Rose *et al.*, 2000). Next to their impacts on the physical habitat, beam trawl fisheries are likely to affect macrophytes and biogenic structures as well, depending on the scale of overlap between the fisheries and the habitat distribution. For shrimp beam trawl fisheries, overlap can be quite substantial and its effects have been illustrated in ICES (2007). Rabaut *et al.* (2007) indicate that species, tightly associated with *Lanice conchilega* reefs, will be impacted significantly when beam-trawling. In general, different mortality rates for benthic species causes a change in community composition and a reduction in species richness.

There are numerous studies showing that there have been long-term changes in benthic community structure as a result of beam trawling (e.g. Lokkeborg 2005; Kaiser *et al.* 2006). The results from studies undertaken to consider recent change are less conclusive. For example, when considering effects on productivity of benthic assemblages, findings are mixed. In muddy habitats the production of benthic communities has been shown to be negatively impacted (Hiddink *et al.*, 2006; Quiéros *et al.*, 2006). Whereas Jennings *et al.* (2002) found negligible effects of beam trawling on infaunal productivity. Beam trawling is also pointed out to have indirect effects on benthic communities, e.g. by changing the food sources (e.g. Ramsay *et al.*, 1996; Franco *et al.*, 2008).

The effect on fish communities has been described as an increased abundance of small fish (all species) as well as increases in demersal species with a low maximum length (L_{max}) over large parts of the North Sea during the last 30 years (Rogers and Ellis, 2000; Daan *et al.*, 2005).

Gill net fisheries

Commercial fish species

Gillnet fisheries are usually more species selective than towed gear fisheries (Gabriel *et al.*, 2005), although in some fisheries up to 101 species have been recorded (Perez and Wahrlich, 2005) whereas in others the catch consists largely of 1 species (Huse *et al.*, 2000). In general the size selectivity of gillnets is high (Huse *et al.*, 1999; STECF, 2006), but there are issues in that these gears tend to target only the large individuals, possibly triggering population/recruitment effects. Discarding by gillnet fisheries is generally low except in fisheries with long soak times for more sedentary species such as anglerfish and turbot (Morizur *et al.*, 1996) where discarding can be higher. Rihan *et al.*, 2005 report discards of over 70% in nets retrieved that were verified as having been abandoned for more than six months. In general, discards are very much dependent on the fishery (gill net type and target species) and the fishing grounds. Increased fishing mortality can be invoked by predation of isopods (Sekiguchi *et al.*, 1981) or seals.

Gillnet fisheries have also been shown to impact on vulnerable species. For example deep water gillnet fisheries in the North-East Atlantic principally target anglerfish (mainly *Lophius piscatorius*), but have a bycatch of vulnerable species, such as deepwater sharks, *Centrophorous squamosus* and *Centroscymnus coelolepis* with severe impact on the stocks of deepwater sharks described (to such a degree that EU and NEAFC have closed these fisheries). Similarly gillnet fisheries targeting localised populations of crustacean species such as crawfish or lobster have also been shown to impact severely on such species over a short period of time (Trent *et al.*, 1997; He, 2005; Large *et al.*, 2009). Gillnets are also widely reported as being an important source of unaccounted mortality through ghost fishing (Brown and Macfadyen, 2007; Tschernij & Larsson, 2003). Levels of unaccounted mortality by ghost nets, however, are reported to be low in inshore waters where nets degrade quickly due to the effects of tide, weather and biofouling and fishing efficiency is reduced quickly. In deeper water there is evidence that such nets continue to fish over much longer periods of time (Hareide *et al.*, 2004).

Listed species including fish, cephalopods and benthos

As for non-commercial species in beam trawl fisheries, listed species ought to be known to make this assessment. Moreover, the distribution range of the listed species is crucial. This is an issue of importance beyond the context of this ToR, and is detailed in the final section on Emergent Issues. Therefore generic impact for benthic invertebrates, non-commercial fish and cephalopods are described, indicating the type of mortality caused by gillnet fisheries for species with comparable traits.

Mortality of benthic invertebrates can be caused through a series of mechanisms for bottom-set gill nets. 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). For non-commercial fish species, no major assessments have been found, although indications of discards exist in some areas (Santos *et al.*, 2002). Gill nets are not known to have any impact on cephalopods, but again, this is an area-specific issue as for instance in Southern Italy there is an "artisanal" fishery directed to cuttlefish (Colloca *et al.*, 2004).

Marine mammals, marine reptiles and seabirds

The by-catch of marine mammals in gillnet fisheries is recognized worldwide as one of the most severe threats (Dayton *et al.*, 1995). The by-catch of small cetacean species and sea otters and the predation of a number of pinniped species, as grey seals, were reported in a number of fisheries (Vinther, 1999; Vinther and Larsen, 2004). However, this impact is very much area- and gear-dependent. For the estimation of its severity, population estimates (abundance, distribution and population health) are needed, but only limited documentation exists. Larger cetacean species can be entangled in buoy lines, e.g. right whale entanglement. Marine reptile by-catch is reported for sea turtles in the Mid-Atlantic monkfish fishery (Chuenpagdee *et al.*, 2003). Seabird species, such as common murres, sea ducks and divers have been by-caught in large numbers (Zˇydelis *et al.*, in press). Gillnet fisheries can pose a serious threat to marine reptiles and seabirds. Again, the degree of impact is strongly gear and area dependent.

Pelagic and benthic habitats and assemblages

The effect of gillnet 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 ground gear (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).

Testing of Methodology developed by WGECO 2008

The methodology developed by WGECO (ICES, 2008b) for the various ecosystem components was modified at WGECO in 2009. This was then used in a test assessment for two case study fisheries; Flatfish beam trawls in the North Sea and bottom set gillnets in the Baltic. Applying the methodology *for real* will require a group of experts covering all ecosystem components for which the generic impact assessment identifies there is a high risk of impact, and who also have local knowledge for the area being assessed. Ideally, a group of three or more experts per component should be available, and an audit trail should be completed as the assessment is undertaken.

Any expert judgement based approach should be accompanied by an analysis of uncertainty to account for the level of knowledge available to support the assessments made for each ecosystem component. Uncertainty is usually recorded as confidence and here we have followed the categorisation of confidence described by Robinson *et al.* (2009) where:

- High confidence should be given when data are available, particularly in the form of GIS outputs for the period being assessed, and/or a group of experts (>3) agree that they have high confidence in the assessment.
- Low confidence should be given where detailed information is not available for the period being assessed, or is not available at all, and/or there is no agreement, or the number of experts involved is <4.

Commercial species

In 2008 target species was defined as those species that the fishing gear is directed at in the geographic area of interest. For example, in the North Sea for beam trawls this would be plaice and sole. On further discussion in 2009 it was recommended that this be re-defined as "commercial" rather than "target" species on the basis that this was much easier to define given that many fisheries by their nature are "mixed" making the identification of "target" species problematic. "Commercial species" is taken to mean any species landed. As a result, there will be data available from logbooks and sales slips on abundance by species and time and area of catch. Some of these species will also be advised on by ICES either through a full analytical assessment or using other state of the stock data such as CPUE time series.

For commercial species, the terminology adopted for the significant adverse impact (SAI) categories is essentially unchanged from 2008 and is analogous to the current definition of B_{LIM} as used in fisheries management, for those stocks where B_{LIM} is defined. Given that B_{pa} represents a value below which the stock is at risk of going below B_{lim}, then a stock below B_{pa} is ***at risk*** of being SAI. No such "at risk of SAI" category exists and for the purpose of this assessment, stocks assessed as being below B_{pa} were classified in the SAI category. By the same process, stocks that are being fished over F_{pa} should also be included under SAI. We have also adapted and used the broader terminology used in the FAO guidelines, as this is inclusive of all target (commercial) species, some of which do not have defined limit or threshold reference points. We have also applied a precautionary approach (for all impact groups) for situations where a lack of information on population size and/or resilience is recorded. Table 4.1 shows the final criteria used.

Table 4.1. Criteria for identification of significant adverse impacts for commercial species (shellfish, fish, cephalopods, macrophytes).

CATEGORY	CRITERIA
No significant adverse impact	Long-term projections imply that population size and recruitment potential are not compromised.
Significant adverse impact	Affecting recruitment levels of stocks/or their capacity to increase such that the ability of affected populations to replace themselves is compromised. No information is available on resilience of the populations.

Outcomes – Beam Trawls in the North Sea

Taking the flatfish beam trawl fishery, based on detailed catch information from the Dutch and Belgium fleets, this metier currently catches 14 commercial species of which 4 are assessed by ICES WGNSSK (ICES, 2008c). For these 4 species the following is the current advice:

- Sole ~90% of catches estimated to be from beam trawls. SSB is currently below B_{pa} and fished over F_{pa}.
- Plaice ~75–80% of catches estimated to be from beam trawls. SSB is currently over B_{pa} and fished under F_{pa}. It was under B_{pa} for the previous 4 years.
- Cod ~20–25% of catches estimated to be from beam trawls. SSB is currently below B_{lim} and fished over F_{pa}. Stock is close to its historic low.
- Whiting ~10% of catches estimated to be from beam trawls. No defined reference points, but at historic low.

Based on this 3 of the 4 stocks can be classified in the SAI category with a high degree of confidence. It should be noted that beam trawls are most important for sole and plaice and less so for cod and whiting

The other 10 commercial species listed, are not currently assessed. In order to judge the status of these species in terms of the SAI criteria, other metrics are required. For instance, CPUE time series from the Dutch fleet are available (van Helmond & van Overzee, 2008) and these could be used as a proxy for the state of these stocks. Where these CPUE series show a consistent decline over time then it is reasonable to assume that these species can be classified in the SAI category. This can be cross-referenced against fishing mortality estimates for some of these species based on the methods developed by Piet *et al.* (in press). This appraisal would require expert judgement from the appropriate community. This will identify the proportion of these species as classified in the SAI or NSAI categories.

Outcomes – Bottom Set Gillnets in the Baltic Sea

Taking the bottom set gillnet fisheries in the Baltic Sea, based on WGBFAS (ICES 2008a) the fleets involved in this metier currently catch mainly cod with a small bycatch of flounder and turbot. Of these species only cod is assessed by ICES (ICES, 2008a).

For cod the following is the current advice:

- Cod ~30% of catches estimated to be taken in gillnets. ICES classifies the stock in subdivision 22-24 as being at risk of reduced reproductive capacity, with the spawning stock just below $\mathbf{B}_{pa}$ in 2008. The cod stock in subdivision 25–32 is estimated to be around 40% below the long-term average (1966–2007). An increase in spawning-stock biomass has been observed since 2005. Based on the most recent estimates of fishing mortality (for 2007) ICES classifies the stock as being harvested sustainably. In addition, there is evidence that fishing pressure is resulting in lower female size at maturity (Andersen *et al.*, 2007).

Based on this the cod stock can be classified in the Significant Adverse Impact category with a high degree of confidence.

For the other commercial stocks taken as a bycatch in this fishery there is currently no assessment. ICES reports the following for flounder and turbot:

- Flounder ~10–15% of catches estimated to be taken in gillnets. No biomass reference points to evaluate the state of the stock. SSB in 2008 is estimated to be around 10% above the long term average. ICES classify the stock as at risk of being harvested unsustainably.

Based on this flounder could be classified in the SAI category at a low confidence level although the relative impact of gillnets on this stock is low.

- Turbot ~5–10% of catches estimated to be taken in gillnets. The state of the stock is unknown and there is no basis for an advice. Landings have declined in recent years, but this should be further evaluated in relation to effort trends to provide LPUE data. Currently there is insufficient information to provide an assessment.

Listed species including fish, cephalopods and benthos

This category applies to all "previously listed" species not already included in commercial species. Table 4.2 shows the criteria adopted for this ecosystem component.

Table 4.2. Criteria for identification of significant adverse impacts for listed species including fish, cephalopods and benthos.

CATEGORY	CRITERIA
No significant adverse impact	For species previously listed as being vulnerable to fishing, mortality[1] is assessed as being sustainable for the population.
Significant adverse impact	For any species previously listed as being vulnerable to fishing, mortality is assessed as being unsustainable for the population. Where any population or species currently assessed to be at risk of extirpation, or otherwise specifically protected by legislation or regulation, suffers any mortality. No information is available on resilience of species, or on mortality rates of the populations in this fishery.

[1]Mortality here includes any mortality in the catch or in the path of the gear (includes on the seafloor and unaccounted mortality of animals passing through the gear).

Outcomes – Beam Trawls in the North Sea

A proper assessment requires an authoritative collation of all previously listed species within the three species groups. Without such a list a full assessment was not carried out, but some guidance is provided below.

For listed benthic species, expert judgement would be required to assess whether this specific metier had an adverse impact relative to the SAI criteria. For listed fish species, analyses such as that by Piet *et al.* (in press) could be used to provide mortality estimates and evaluation against the SAI criteria. This information could be supplemented by information from beam trawl surveys in the southern North Sea, in particular declines in cpue and in area occupied. There is little evidence for any impacts on cephalopods.

Outcomes – Bottom Set Gillnets in the Baltic Sea

The same conclusion applies here as for the beam trawl case.

Marine mammals, marine reptiles and seabirds

Suggested acceptable bycatch mortality for marine mammals of 1.7% of the population annually has been proposed by ASCOBANS (Anon. 2000), and would be a suitable candidate for differentiating SAI and NSAI for these species. State indicators for seabirds generally focus on abundance and/or breeding success. Fishery impacts are generally seen in the context of competition for forage fish e.g. sandeels in the North Sea, resulting in potential declines in breeding success and hence abundance. Many seabird species are known to forage on discarded fish and offal from fishing activity. In light of this, a criterion relating to increases in populations above reference levels has also been included as described by ICES (2008b). For seabirds under the proposed EcoQO this is set at 130% above reference levels. A similar criterion may also be applicable to other marine mammals. Table 4.3 details the criteria used for this ecosystem component.

Table 4.3. Criteria for identification of significant adverse impacts for marine mammals, seabirds and marine reptiles

CATEGORY	CRITERIA
No significant adverse impact	No/negligible impact to any population or species (for example, mortality below the unacceptable level[1] where defined).
Significant adverse impact	Affecting the capacity of populations such that their ability to replace themselves is compromised. This point should be defined by the unacceptable level[1] where defined, and where any mortality above the unacceptable level is deemed to cause a significant adverse impact. Where any population or species currently assessed to be at risk of extirpation, or otherwise specifically protected by legislation or regulation, suffers any mortality. No information is available on resilience of species, or on mortality rates of the populations in this fishery.

[1] The unacceptable level will depend on which component you are considering. For example, unacceptable levels have been defined for some species of marine mammals, such that in the OSPAR area the mortality rate can not be >1.7% of the population in any fishery (Anonymous, 2000). Changes in breeding seabird abundance should be within target levels for 75% of the species monitored in any of the OSPAR regions or their sub-divisions OSPAR 2008 (OSPAR, 2008).

Outcomes – Beam Trawls in the North Sea

According to all documentation reviewed and also based on information collated by ICES SGBYC (in prep.) there is no known bycatch of marine mammals, seabirds or marine reptiles in the beam trawl fishery in the North Sea.

Some seabird populations are known to utilise discarded fish and/or offal. Adverse impacts could therefore include increases of more than 130% above reference levels. The critical point would then be the chosen reference levels. Until this is settled, an evaluation against this criterion cannot be made.

Based on the above, this group would be classified as having NSAI with a high degree of confidence.

Outcomes – Bottom Set Gillnets in the Baltic Sea

According to HELCOM 2007, bycatch in bottom set gillnet fisheries represents a major threat to the recovery of the harbour porpoises in the Baltic. This species is listed on the HELCOM list of threatened and/or threatened species. The annual bycatch of harbour porpoise is roughly estimated at 7–10 individuals of which more than 75% is attributed to bottom set gillnet fisheries. According to ICES (2006) fisheries bycatch historically amounted to 0.5–0.8% of the porpoise population in the south-western part of the Baltic Marine Area each year, as well as 1.2% of the porpoise population in the Kiel and Mecklenburg Bays and inner Danish waters (Kock and Behnke, 1996). Estimates of the harbour porpoise population are uncertain, however, and the number of porpoises by-caught in fisheries is probably underestimated but given that the population is estimated at only 200–1000 individuals (HELCOM, 2003) this could be classified as a SAI with a low level of confidence, due to the level of uncertainty in the population estimate.

For the other three marine mammal species found in the Baltic, namely the Ringed seal, Grey seal and Harbour seal, HELCOM (2007) estimated that at least 300 grey seals, 80 ringed seals and 7–8 harbour seals are captured as by-catch annually in the Baltic Sea, mainly in the salmon drift net fishery. Further estimates are available for the Swedish Baltic Sea drift net fisheries where Luneryd *et al.*, (2005) reported over 400 grey seals and 50 ringed seals by-caught in 2001. These were mainly attributed to the salmon drift net fishery although there was also evidence of bycatch in the cod gillnet fishery. Helander and Härkönen, (1997) showed population increases in these species despite these mortality figures suggesting that it is below critical levels (1.7%). Therefore gillnets could be classified as having No Significant Adverse Impact on these species, at a low level of confidence given the uncertainty surrounding population sizes and actual bycatch levels.

Several studies reported by HELCOM have shown that the gillnet fishery in the Baltic Sea can in certain places cause high seabird mortality

(http://www.helcom.fi/environment2/biodiv/fish/en_GB/effects/).

The by-catch problem is of special relevance where the gillnetting is carried out in the areas with high concentrations of resting, moulting or wintering seabirds. Bycatch of piscivorous birds (divers, grebes, mergansers, auks, cormorants) and benthophagic ducks are reported although not all this bycatch is attributable to gillnets. Gillnets also cause mortality of long-tailed ducks (*Clangula hyemalis*), velvet scoters (*Melanitta fusca*), eiders (*Somateria mollissima*), and black scoters (*Melanitta nigra*). There are also widescale reports of guillemot and razorbill (*Alca torda*) mortality in the driftnet fishery for salmon (HELCOM, 2003). The majority of these species are listed on the HELCOM list of endangered or threatened species, therefore gillnet fisheries can be classified as having Significant Adverse Impact on seabirds with high confidence.

Pelagic and benthic habitats and assemblages

For habitats, criteria for significant adverse impacts were adapted from the FAO terminology about deterioration of productivity, and risk of permanent local loss and are largely unchanged from 2008. The definition of "damage" as defined by Robinson *et al.* (2009) was as follows:

"Damage can be judged to have occurred where there has been a change in, or loss of, typical or natural elements (e.g. species, physical structures) of the habitat relative to former natural conditions such that structure and/or functioning of the habitat is altered. In terms of a change in biological structure (e.g. species composition), damage is assumed to have occurred where several typical species of the assemblage have been extirpated from the area. This does not include short-term fluctuations in species whereby a species may be present in one year, absent in the next and present the following year. It must be an example where there has been a sustained change in the composition of species."

Terminology on structure and function (see Chapter 3 in this report for ToR a) is also included in the criteria, in recognition that these are equally important characteristics of a habitat and that long-term degradation of productivity, structure or function should be considered a significant adverse impact (Table 4.4.). The FAO Guidelines (2008) identify serious adverse impacts to habitats as impacts where recovery takes longer than 5–20 years. Priorities for gear technologists to address should be based on impacts that are expected to persist several years or longer, with consideration of natural conditions that affect physical and biological processes. Again presence of features of habitats that are protected and/or currently assessed to be at risk of extirpation were also considered as criteria for significant adverse impacts, and the precautionary approach would be applied where limited information or understanding was encountered (Table 4.4).

Table 4.4. Criteria for identification of significant adverse impacts for habitats, incl. macrophytes and biogenic habitats (horse mussel beds, coral reefs etc.).

CATEGORY	CRITERIA
No significant adverse impact	Any impact on productivity, structure and function of natural habitats exposed to the gear (e.g. in the towpath or snagged damaged hauling or shooting the gear) would have fully recovered[1] in 5–20 years, dependent on natural background conditions.
Significant adverse impact	Any impact on the long-term productivity, structure and function of natural habitats, such that recovery would not occur in 5-20 years, dependent on natural background conditions. Where any habitat currently assessed to be at risk of permanent local loss, or has features that are otherwise protected by legislation or regulation, suffers any damage or degradation of conservation status. No information is available on habitat types in the area that the fishery operates in.

[1]Here we have adapted the terminology used in the FAO guidelines (FAO, 2008). Some of the terms used (e.g. fully recovered) are not clearly defined yet and it will be essential to complete those definitions before these tables can be made fully operational (see recommendations and ToRs for 2009).

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 ground gear. 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 gill net 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.

The assessment outcomes by gear type and ecosystem component group are summarized in table 4.5

Table 4.5. Assessment outcomes by gear type and ecosystem component group

Ecosystem Component Group	Beam Trawls in the North Sea	Bottom Set Gillnets in the Baltic Sea
Commercial fish species	SAI for sole, cod and whiting NSAI for plaice No evaluation for unassessed species	SAI for cod and flounder No evaluation for turbot
Listed species including fish, cephalopods and benthos	No evaluation due to no agreed list	No evaluation due to no agreed list
Marine mammals, marine reptiles and seabirds	NSAI	SAI for harbour porpoise and seabirds NSAI for seals
Pelagic and benthic habitats and assemblages	SAI for impact on productivity, structure and function of habitats except pelagic SAI for impact on benthic and fish assemblages	NSAI for any impacts

Emergent issues

In carrying out the assessment, a number of difficulties arose that may have resonance for other assessments both for gear, and for other pressures.

- What is the minimum level of proportional impact that would constitute an important pressure? For example, if a particular gear, caught less than 5% of a fish stock that was below B_{pa}, would that gear pressure be assessed as a "cause" of that SAI evaluation? Equally, while beam trawling is acknowledged as having a major impact on the North Sea habitats, this will compounded with otter trawl impacts that are also acknowledged as major (Kaiser *et al.*, 2006, Løkkeberg, 2003).
- Standard reference points for assessed fish species are B_{pa} and B_{lim}. We have indicated here that when a stock is over B_{pa} in the current year, it can be considered as NSAI, even when it has been below B_{pa} over a number of previous years. Is there a need for a time scale factor, e.g. "has been below B_{pa} for 4 out of the last 5 years"?
- Again, we assessed stocks below B_{pa} as SAI. However while B_{pa} requires reduced fishing to allow recovery, SAI requires a complete halt to the responsible activity. The two concepts are not mutually compatible in terms of response.
- What are the appropriate "natural" reference conditions? OSPAR defines these as "pre-industrial". But for instance, beam trawling in the southern North Sea was responsible for permanently modifying the physical habitat

many years ago; removal of boulders and oyster beds. This is likely to be irreversible. Is it sensible to permanently assign an SAI category on this basis? Or should we consider more recent impacts and take the reference as the modified habitat? Similar questions arise for seabirds and other components (see discussion in Section 6 of this report).

- What geographic extent constitutes an important impact? If one small area is very seriously impacted, but the rest is largely pristine, how does one assign SAI/NSAI? The distributional ranges for vulnerable or endangered species are particularly important in this context; e.g. is the species endangered across its range or locally.
- In many species cases, especially fish, a whole stock for a species may be below B_{pa}, and therefore in an SAI status. At the same time, it may be possible that individual pressures e.g. from different gears do not make an important contribution to that status assessment. Equally, one stock of a species may be SAI, while another may not. There is probably a need for a nested approach to such species evaluations.

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Annex 7: WGFTFB information for other ICES expert groups – questionnaire sent to WGFTFB members

Incorporation of Fishing Technology Issues/Expertise into Management Advice

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 etc 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 fishermen 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 for fisheries and ecosystem based advice, co-sponsored by Dominic Rihan (Ireland), Dave Reid (Scotland) and Norman Graham (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

Norman, Dave and 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 recognised.

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 and keep your comments restricted to information in the period 2007–2009.

a. Changes in Fleet Dynamics between **2007 and 2009**

Have there been any major shifts between mesh categories (e.g. from 100mm+ to 70 – 90 mm) and in which ICES area has this occurred?

What are the principal driving factors for this change? (E.g. effort allocation, fuel costs)

Is there a geographical shift in activity (e.g. between IV to VI – give the subdivision if possible)?

Within a particular mesh/gear category, has there been any shift in target species (e.g. from demersal gadoids to anglerfish; sardine to tuna etc)

Has there been any removal of effort through decommissioning schemes, of so which fleets have been affected and has the decommissioning affected older or newer vessels or a combination of both?

What proportion of the fleet has opted for decommissioning (express as a percentage of the total 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?

c. 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?

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 by-catch)

What proportion of the fleet has opted to use new TCMs (0–5; 5 highest)

Please specify regulation (national or otherwise) and fishery.

d. Ecosystem Effects

Are there any fisheries where there are known impacts on non-target species including birds and marine mammals, ghost fishing etc?

Are there any mitigation measures in place and how effective have they been?

e. Development of New Fisheries

Briefly describe any new fisheries developed?

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 email 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 during the WGFTFB meeting into a common format.

WGFTFB report to WGCSE

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, France, Spain (Basque region only) and Portugal. Limited information was received from the UK England, Wales and Northern Ireland.

Fleet dynamics

- All countries have reported very low prices for fish and shellfish. Indications that prices for some species have dropped by as much as 50% on 2007 levels. Many vessels have tied up because of low prices in 2009. This is compared to 2008 when vessels tied up because of high fuel prices. Traditional Spanish and French markets are particularly depressed. Imports and the world recession are the main reasons given (All countries: Implications: Low prices leading to reduced effort).
- In the Rockall fishery in Area VIb, three of the largest Irish whitefish vessels 30m+ in length and with> 1000hp have all left the fleet during the last quarter of 2008. These vessels collectively exerted a lot of effort in this fishery (over 500 days of effort). However, at least three smaller 24m/600hp vessels from the south coast have participated in this fishery for the first time in 2009, negating this reduction to some

degree. New technical measures regulations in part of VIa have also meant that some vessels participated earlier in the year in the Rockall fishery than previous rather than fish in VIa (Ireland: Implications: Reduced effort in Area VIb).

- The new days at sea regulations have caused serious problems for many vessels in the Irish fleet given under the first pilot period of February to the end of April 2009 many vessels received very small effort allocations. This has resulted in wide spread effort shifts from Area VIa and VIIa into Area VIIb-k. In particular there has been increased effort in the *Nephrops* fisheries in Area VIIg and VIIb. In VIIg at least 5 vessels of around 24m/550hp have been forced to move from VIIa to VIIg and VIIb due to the fact this were replacement vessels for owners who had decommissioned. These vessels had no track record and so got no entitlements in VIIa (Ireland: Shift of effort from VIIa – VIIg and VIIb).
- The new technical measures in a substantial part of Area VIa, which require the use of increased codend mesh sizes and square mesh panels have resulted in a significant drop in effort in Area VIa since the beginning of 2009. Since January it is estimated that only two of the larger whitefish vessels in the NW have fished inside the restricted area and have reported catch reductions of between 30–40% of all species with the new mesh sizes. These regulations have also caused effort to be shifted to the Rockall fishery as mentioned as 3–4 of the larger whitefish vessels have been forced to participate in this fishery from February/March onwards rather than April as in previous years. It seems likely that effort in VIa will be at a very low level during 2009 as it is uneconomic for vessels to fish with the larger mesh size codends (Ireland: Implications: Shift of effort out of VIa into Rockall).
- In 2008 due to the days and fuel used steaming to Rockall many Scottish vessels which would have targeted these grounds instead targeted west coast or North Sea grounds. A few vessels made single trips to Rockall but the returns were poor and therefore proved a disincentive to other vessels making the long journey. From 1st February 2009, however, many of these Scottish vessels have now reverted back to the Rockall grounds which has now become attractive due to the steaming and fishing time not counting against days at sea days at and because fuel costs have reduced. These vessels are targeting haddock, anglerfish and megrim; however, this could lead to a quick uptake of Rockall quotas (Scotland: Implications: Shift of effort from Rockall (VIb) to IVa (North Sea) and vice versa and quick uptake of quotas).
- Up to 3–4 Scottish vessels have also moved from the North Sea and west of Scotland to Area VIIb-k in 2008 and 2009. These vessels are all large vessels 24m+ and are targeting *Nephrops* at the Porcupine Bank and Labadie Banks. This is thought motivated by the fact that there aero no days at sea limitations in VIIb-k (Scotland: Implications: Shift of effort into VIIb-k).
- Due to the new by-catch limits (30%) introduced from February 2009 as part of the new technical measures in Area VIa, the west coast grounds, inside the 200 m line, are effectively closed to Scottish ves-

sels, with whitefish vessels fishing outside the 200 m line or shifting to North Sea grounds. The effort shift associated with this is expected to be large (Scotland: Implications: Shift in effort from VIa inside the French Line to Area VIa and IVa).

- The codend mesh size for smaller vessels (< 15 m) on west coast grounds has increased from 100 mm to 110 mm. As a result some (> 20 Scottish vessels) of those which targeted megrim have moved to other areas, particularly the North Sea as these vessels are too small to target Rockall (Scotland: Implications: Shift of effort from Area VIa into other areas).
- The new regulations in Area VIa have also affected Scottish Seine net vessels, which are now on a one net rule and have to use the whitefish codend mesh size of 120 mm. This has effectively closed the fishery for these vessels and forced them to tie up or shift into the North Sea (Scotland: Implications: Shift of effort from Area VIa to other areas).
- The new 200 m French line has caused problems for Scottish vessels due to it zigzagging down the west coast and therefore not following the 200 m depth contour but running over shallower (150 m) and deeper water (350 m). This has lead to vessels having to complete many log-sheets for a single fishing trip due to repeatedly crossing over the line. An added complication is that within the 200 m line they must have the 120 mm SMP fitted, while outside they don’t (Scotland: Implications: Control and Enforcement issue).
- The decommissioning scheme introduced in Ireland in 2008 has now been completed. A total of 19,041kw and 6,818GT was removed from the fleet from the 45 vessels decommissioned under this scheme. In total Ireland has removed 72 vessels of 10,141 GT since 2005. The majority of vessels scrapped came from East and west coast ports from vessels which traditionally target *Nephrops* with uptake from the East and South East (Irish Sea/Smalls *Nephrops* fishery and beam trawl fleet) and the west coast (Aran and Porcupine *Nephrops* fisheries). Very few applications were received from the South coast which traditionally target whitefish. Much of the actual effort removed from the decommissioning scheme, however, has been partially negated through the introduction of ~25 modern second hand vessels (mostly ex-French) into the fleet and also a number of 12–18 m vessels. These have either replaced existing older, less efficient vessels, or owners who have taken advantage of ‘semi-dormant’ tonnage in Ireland (Ireland: Implications: Reductions in Fleets but actual impact unknown).
- There has been a decommissioning scheme in France that has removed a number of 24 m+ whitefish vessels that targeted mixed demersal species including cod in VIIb-k. The actual amount of GT and KW that has been removed but is reported to be significant (France: Implications: Reductions in demersal fleet).
- In 2007 there were 17 boats (8 fishing units) in the Basque fleet operating with VHVO trawls targeting hake in VIIIabd. In 2009 this has been reduced to 6 boats (3 fishing units). Approximately half of the VHVO fleet has opted for decommissioning, some others were sold to other Cantabrian regions (Galicia) were they change to other fishing

gears (single trawl or gillnets) (Spain: Implications: Reduction of 50% in one sector).

- There has been a widespread decommissioning scheme in Portugal mainly targeting trawlers and polyvalent vessels within the scope of the recovery plans for southern hake and *Nephrops* stocks. 17 trawlers will be decommissioned by November 2009. The scheme will reduce the coastal fleet by about 16% (Portugal: Implications: Reduction in fleet size).
- The Belgian fishing fleet numbered 102 fishing vessels in the beginning of 2008 and has now been reduced in 2009 to 98 active vessels due to 4 vessels going bankrupt (Belgium: Implications: Reduction in fleet size).
- Irish vessels have reported increased activity by the Russian fleet prosecuting a small mesh fishmeal fishery for haddock both inside and outside the EU 200 mile limit at Rockall. These vessels have been observed on the grounds much earlier than in previous years. In 2008 there was a peak in haddock abundance in April but in early May haddock were reported scarce and the Russian vessels left the grounds. Russian activity has been reported to be fairly limited in 2009 (Ireland: Implications: Increased effort on Rockall haddock stock).
- There are now 5 Irish vessel freezing *Nephrops* on board. These vessels are all in the 20–24m/500–700hp size range. They are fishing with twin rig double bag trawls and are doing long trips of up to 14 days duration. These vessels are only retaining on board large grade *Nephrops* (0–10 count per kg) as well as monkfish tails and headed cod. No other catch is retained on board including species such as haddock, flatfish, hake and John Dory. These vessels do however fish with 100mm codends so discarding of *Nephrops* is slightly reduced due to increased selectivity. A further 6 vessels are currently being fitted out with freezing systems (Ireland: Increased effort and discarding of marketable fish).
- There are 3 French vessels and approximately 10 Dutch vessels (with a further 3 under construction) that have switched to Scottish seining. These vessels are around 24m+/650hp–1200hp. The French vessels have reportedly been targeting whiting in particular but also cod and non-quota species in Area VIIb-k (mainly VIIg) for the 1st and 2nd quarter of 2009. These vessels, along with the Dutch vessels are also working in VIId and IVb for non-quota species such as red mullet, squid and gurnard. They are fishing with ~50mm diameter seine rope and are hauling the last two coils of the “ring” at 5 knots compared to 1–1.5 knots by Scottish and Irish seiners. These vessels can complete up to 8-10 rings in a day compared to 5 or 6 by Scottish and Irish vessels. This represents a considerable increase in effort in this fishery (France and Netherlands: Implications: Increased effort in VIIb-k whitefish fisheries).
- Mainly due to the high fuel price in 2008 the owners of several larger Belgium beam trawlers went bankrupt. This coupled with the fact that the high cost of fuel meant a number of vessels did not travel to the Celtic Sea. This reduced effort by this fleet by about 30–40% in this

area and particularly in the period after the Trevose Head seasonal closure was re-opened at the beginning of May. Traditionally these vessels concentrate efforts in the Celtic Sea. During 2007/2008 5% of the Belgium beam trawl fleet was removed through decommissioning. (Belgium: Implications: Reductions in Fleets but actual impact unknown).

- Fewer Belgium beam trawlers have fished in the ICES-zone VIII (Gulf of Gascogne) in 2008 and 2009, mainly due to high fuel costs in 2008 and a lack of quota. The vessels have tended to stay in the North Sea (Belgium: Implications: Shift of effort from VIII to IV).
- During quarter 4 of 2008 there was a considerable increase in effort on the *Nephrops* fishery at the back of the Aran Islands off Galway in Area VIIb with up to 40 vessels participating in the fishery for a period of 3–4 weeks. High landings of mostly "tails" were recorded during this period. These boats shifted from the Porcupine, Smalls and Labadie fisheries during this time (Ireland: Implications: Shift in effort from different *Nephrops* fisheries into Area VIIb).
- There have been a number of effort shifts in the French fleet over the period 2008/2009. Due to the anchovy ban, low prices for tuna and concerns over the sea bass fishery, a number of vessels have switched form pair trawling (~10 pairs) to bottom trawling for monkfish, megrim and *Nephrops* in the Bay of Biscay VIIIa / VIIIb. There has also been shift by a few vessels from bluefin tuna purse seining to bottom trawling or Danish seining in the Bay of Biscay VIIIa / VIIIb (3 vessels in total). During 2008 due to high fuel costs there was also as shift from *Nephrop*s twin trawling to single rig trawling by a large number of smaller trawlers in the Bay of Biscay VIIIa / VIIIb (France: Implications: Shifts in effort into a number of fisheries).
- Two Belgium beam trawlers converted to scallop dredging in 2008, although 1 of these vessels has since reverted back to beam trawling due crew problems (Belgium: Implications: Shift from beam trawling to scallop dredging).
- In 2007 there were more or less as many Belgium beam trawlers changing between flatfish and shrimp beam trawl fisheries as in 2006. However, due to reduced landings in 2007 landings of brown shrimp (*Crangon crangon*), effort was reduced quite significantly. In the second half of 2008, the landings of shrimp have increased again and effort by beam trawlers has increased in this fishery (Belgium; Implications: Fluctuating effort in the *Crangon* fishery).
- The high price of fuel and the low price of the fish in 2008 has led to a reduction of fishing effort by the Basque trawling fleet The boats opted to tie-up for longer periods than in previous years during the summer months (Q3) (Spain: Implications: Reduced effort).
- Some minor changes of effort in 2007/2008 have been noted in the Basque trawl fleet from VIa to VIIIab, due to reduction of blue ling quota and from VIIIab to VIa in 2008/2009 due to better catches of anglerfish, megrim and hake (Spain: Implications: Shifts in effort from VIa to VIIIab).

- There have been shifts in bottom trawler effort in the Basque fleet (Single and VHVO nets) from demersal species (monkfish, hake, megrim, squid, red mullet) to mackerel in VIIIabd for a short period of time in early winter (Q1) induced by good prices for mackerel. Approximately 6–8 vessels have been involved (Spain: Implications: Shift from demersal to pelagic species).
- There has been a shift of targeted effort of the Basque purse seining fishing fleet in ICES VIIIc from anchovy (closed fishery since 2006–2007) to mackerel with purse seines in early spring and to pole and line for bluefin tuna fishing during early summer. Again this shift in effort has been significant (Spain: Implications: Shift from anchovy to mackerel and tuna).
- Individual transferable quotas have been introduced into the Portuguese fleet since 2007 to manage annual TACs for southern hake. Allocations have been based on historical landings for all vessels independent of their inclusion in the recovery plan for southern hake and Norway lobster. Indications the system is working quite well (Portugal: Implications: New management measures).
- Several larger French trawlers using mesh size range 70–99 mm have moved further north in the North sea (south east 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).
- French trawlers using 70–99 mm fishing in VIId and IVb have increasingly targeted red mullet, sea bass and squids to offset lower catches of cod, whiting and plaice). Other vessels including Dutch and Belgium beam trawlers and Dutch seiners are also targeting these species at high effort levels (France: Implications: Targeting of different non-quota species).
- There has been a significant decrease in effort in the North Sea in 2008/2009 by Northern Irish vessels. Many vessels stayed in the Irish Sea due to high fuel prices and also in 2009 due to uncertainty about the days at sea allocations. (Northern Ireland Implications: Increased effort in VIIa).
- The gillnet fleet in Newlyn has tied up in April/May because of the very low prices for hake currently. Hake are abundant but prices have dropped to €2/kg even for good quality fish (UK: Implications: Voluntary tie-up).

Technology Creep

- A number of vessels have started to use trawls with Dyneema headlines of 10–12 mm. This has reduced the overall drag of their gear and is motivated by high fuel costs in 2008. One seine net vessel reports a reduction in fuel consumption of around 400 litres per day fishing (Ireland; Implications: Improved fuel efficiency).
- There has been an increase in the use of double bag trawls in the *Nephrops* fisheries in VIIb-k. These nets have a wide bosom section and are very effective at catching *Nephrops* (Ireland: Implications: increased catching efficiency).

- A large number of French bottom trawlers in the Gulf of Lyon have significantly reduce their trawl size by up to 20% or shifting from single rig trawling to small twin trawling to reduce fuel costs (France: Implications: Improved fuel efficiency).
- 3 Scottish seiners are now fitted with seine power reels that allow them to haul without using a seine winch. This considerably increases the efficiency of the operation and allows an extra haul per day. These vessels are currently working in the North Sea but this could spread to the west of Scotland at a later date. Most of the French seiners working in VIIb-k are also using this system (Scotland ad France: Implications: Improved efficiency in seine net fisheries).
- In 2009 more and more Belgium beam trawlers are using roller gear instead of the standard trawl shoes to reduce fuel consumption. About 3 vessels are also investigating the Dutch sumwing bam trawl to reduce fuel consumption as well. It is expected that this initiative will lead to gear modifications used in beam trawls, depending on legislation changes (Belgium: Implications: Adoption of fuel efficient gear).
- Belgium beam trawlers are increasingly being equipped with 3D mapping sonar which has opened up new areas to fishing close to wrecks and areas of hard ground (Belgium: Implications: Increased access to unfished areas).
- A few old side trawling vessels (between 10% and 20% of the Basque trawl fleet) have been replaced by new stern trawlers in the period 2007–2009. In fact since 2000 most of the trawler and longliner fleet has been renewed (Spain: Implications: newer, more efficient vessels).
- In the Basque fleet there has been a recent introduction of vacuum pumps to handle fish in the purse seine fishery for mackerel in VIIIc. This mainly to optimize fish handling and reduce processing time at sea. One of the main aims of the technological creep has been the improvement of safety and comfort of the crew. No estimation on catchability has been carried out so far although the main proven effect is the reduction in the time spent to handle the catch and subsequently the haul duration. Triplex haulers have also been fully implemented in the purse seine and pole and line fleet segment in VIIIc. Net clearers have been implemented in an important number in the coastal gillnetters (artisanal fleet) in VIIIc (Spain: Implications: New technologies increasing efficiency at sea).

Technical Conservation Measures

- A number of the larger *Nephrops* vessels (5–6 vessels) fishing on the Labadie and Jones Bank have begun to use 100 mm codends both north and south of the 51°N line and in an effort to reduce catches of small *Nephrops* (Ireland: Improved Selectivity).
- Several Irish vessels fishing in the Irish Sea during the 2009 cod closure got into trouble with the Irish Naval Services over the rigging of their inclined separator panels. The panels being used did not match the legislation currently in force but the owners and local net makers pointed out that for small trawls it is impossible to install the panels as per the legislation. A common sense approach was adopted subse-

quently given the vessels in question were trying to fish selectively with the panel (Ireland: Implications: control and enforcement issue).

- The new technical conservation measures introduced into Area VIa inside the so-called French Line have caused great difficulties for Irish vessels, due to the imposition of a one net rule that means vessels can only carry gear of one mesh size. If they fish inside the French line they must use 120 mm codends + 120 mm SMP but even though they can fish legally outside the line with 100 mm mesh they can't carry this gear on board while inside the restricted area (Ireland: Implications: One net rule).
- The new rules have also meant effectively that small vessels fishing in local grounds off Greencastle have had to increase mesh size from 80mm to 110 mm with a 110 mm SMP in a very short period of time. This codend mesh size is claimed to be unviable for these small vessels due to very low catch rates although this has not been tested (Ireland: Implications: Increased mesh size for small vessels).
- There are around 12 vessels working under a special permit scheme operated in Ireland which allows them extra monkfish quota but limits catches of certain other species including *Nephrops*. Participants must also stop all whitefish and pelagic fishing activity for a period of 28 days in the months June to September although they can fish for albacore tuna. There are reported to be up to 5–6 of these vessels targeting monkfish with codend mesh sizes of > 120 mm mesh size (Ireland: Implications: reduced discarding).
- The majority of Scottish *Nephrops* vessels working in VIa are rigging their 120 mm SMP into the end of the tapered section of the trawl. To ensure the SMP was at the correct legal position (15–18 m) the straight extensions are shortened. For vessels which may target fish during a particular cruise the panel will be positioned in the tapered section with the rear most meshes of the SMP at 9 m from the codline. It has not been assessed what the effect of this will be but it is likely that the panel is not as effective for reducing haddock and whiting discards (Scotland: Implications: Not fully known).
- From 2009 many Scottish *Nephrops* vessels targeting west coast grounds in VIa have been using 160 mm SMP's to demonstrate to the Commission that they are definitely not targeting fish and have moved to a single species fishery. This has been driven in part by concerns for the potential of the Swedish grid being imposed on west of Scotland *Nephrops* fishery if quotas are used up towards the end of 2009 (Scotland: Implications: use of more selective gear).
- For vessels in the new Scottish Conservation Credit Scheme the minimum SMP mesh sizes for *Nephrops* vessels from 1 Feb 2009 are 120 mm @ 12–15m for west of Scotland grounds (VIa) and 110 mm in North Sea grounds (IVa). The use of this gear is now mandatory under the Conservation Credit Scheme. It has been estimated that the 120 mm SMP gives a 30% increase in L50 of haddock, whiting and saithe. Smaller increase in L50 of perhaps 10% for cod are likely but only if the panel is put close to the codend (Scotland: Implications: Improved selectivity).

- French vessels working in the Bay of Biscay VIIIa & VIIIb have been using a combination of increasing mesh size from 70 to 80 mm; using drop out panels on the bottom sheet of the extension of the trawl (Square mesh with 60 mm bar size) or using flexible *Nephrops* grid with 13 mm bar spacing. Trials have shown a reduction of *Nephrops* discards (below 9 cm total length) of 35% for the 13 mm grid, 30% for 80 mm, 25% for square mesh drop out panel. The use of these devices is voluntary (France: Implications: Improved selectivity).
- French vessels have been allowed to use a 70 mm mesh size in the Hake Box in the Bay of Biscay instead of 100 mm, if they use a 100mm square mesh panel in the top of the baitings. This is based on trials carried out by IFREMER in conjunction with the French industry which showed a reduction of hake discards (below 27 cm) of 25%. This modification has been allowed since 2008 with a large uptake (France: Implications: Use of TCM as an alternative to larger mesh size codend).
- There has been voluntary use of 100 mm square mesh panels by Basque vessels aimed at reducing the level of discards on the trawl fishery targeting mixed demersal species in some areas of ICES VII-Iabd close to the French coast. No assessment of the impact of this has been carried out (Spain: Implications: Possible improvements in selectivity).
- There has been a reduction of the quota and increase of the MLS for bluefin tuna in pole and line fishery to 8 kg and in recreational fishery to 30 kg. For 2009 and pole and line fishery targeting bluefin tuna fishery will be closed until 15 June. These regulations are having an impact on the Basque fleet as options for these vessels are now very limited due to closure of the anchovy fishery (Spain: Implications: Increased regulations to protect tuna).
- A number of BRDs have been tested to mitigate discards in crustacean trawling (project NECESSITY, national project MARE) in Portugal. These include a sorting grid system to exclude fish by-catch; a second one to sort out immature *Nephrops*; and also a square mesh codend. No uptake by industry has been observed (Portugal: Implications: Testing of selectivity devices).
- Effort in the deepwater gillnet fisheries for hake has remained very high in 2009, particularly in the south-west Porcupine area. Changes to the regulations allowing the use of 100 mm mesh size but with a reduced net lengths and reduced effort do not seem to be working as effort seems to have increased from 2008. There has been increased monitoring of these vessels by the Irish Naval Service and one vessel recently arrested was found to have nearly 1 tonne of hake roe on board in addition to the hake catch of more than 18 tonnes. The majority of hake being retained are small fish in the 0–500g or 500–1kg size grade. (Ireland: Implications: Reduced selectivity through the use of small mesh size).
- As in 2007, Irish vessels are now discarding 0–500g and 500g–1kg monkfish to meet quota restrictions. This discarding is reportedly at quite a high level, particularly in around 200 m – 400 m on the Achill grounds and Stanton Banks. As reported, however, some of these ves-

sels are now using large mesh codends to reduce discarding (Ireland: Implications: High discarding).

- The Producers' Organisation in Belgium has set up a working group of ship owners to test gear modifications to beam trawls. The testing is partial funded nationally and partially voluntary testing. Gear modifications tested include a square mesh panel in the upper-aft of the trawl and bigger diamond meshes in the top panel. Both modifications have been tested in the Central North Sea in 2009 to reduce the by-catch of unwanted roundfish, particularly whiting and cod. Beam trawler (1200hp) fishing in the Irish Sea is using a combination of T90-codend, benthos release panel, big meshes in the top panel and roller gear. These modifications have been tested in 2006 on a project scale and are now used by the same vessel on voluntary basis (Belgium: Implications: Voluntary adoption of TCMs).

Ecosystem Effects

- High discarding of cod in Area VIIb-k was reported in Q3 and Q4 in 2008 due to exhaustion of quota. This is likely to be repeated in 2009. Discarding has been widespread across all Irish demersal fleets. An example of the scale is reports from the owner of one seine net vessel, who discarded over 30 boxes of marketable cod (1–1½ tonnes) from one 5–6 day trip. The problems in 2008 have been put down to poor quota management which effectively led to unrestricted landings during February-March. Heaviest landings were made by the Irish gillnet fleet of around 6–8 vessels. Heavy landings led to very low prices and cod were sold as low as €1.20–1.40/kg during this period. (Ireland: Implications: High discarding).
- During Q1 of 2009 there have been large quantities of mackerel in Area VIa both inside and outside the French Line. All of this fish is being discarded due to quota restrictions and is reported to be on a wide scale. During trials on an Irish vessel in April catches of up to 4 tonnes per tow were recorded (Ireland: Implications: discarding of mackerel).
- There is a high abundance of hake in and around the 200 m line in Area VIa, mainly outside the French Line although hake seem to be widespread. Catches of up to 1–2 tonnes of marketable fish (mainly 1–2 kg and 3–5 kg grade fish) have been reported consistently since March by Irish and Scottish vessels working in Area VIa. However, due to low market prices there has been high discarding of hake below 40 cm. (Ireland and Scotland: Implication: Increased abundance of hake).
- Boats entering the Trevose closed area in Area VIIg, statistical rectangle 32E3 had very poor catches when this box re-opened. There seem to be an abundance of lesser spotted dogfish. Catches did improve after the box was re-opened (Ireland: Implications: effectiveness of closed area).
- Monkfish catches in the Rockall fishery Area VIb were reported to be increased in Q1 and Q2 of 2009. Fish seem to be abundant with catches of up to 1 tonne from some hauls. (Ireland: Increased abundance of monkfish in Area VIb).

- High catches of cod have been reported from the Jones and Labadie Banks in Area VIIj during Q2 of 2009. Cod seem to be particularly abundant in an area not normally associated with this species. Catches in excess of 5 tonnes per tow have been reported by a number of vessels targeting *Nephrops* in this area. All cod caught seem to be large fish (Ireland: Implications: Abundance of cod in a new area).
- IFREMER in France along with the industry are continuing to do extensive testing of acoustic deterrent devices in French pelagic and gillnet fisheries. The results have been mixed but reductions in cetacean bycatch of between 40–60% have been observed in the bass fishery (France: Implications: Reduction in cetacean bycatch).
- There has not been a major shift in mesh size categories (anecdotic information) although some of the Belgian beam trawler fleet have been fishing with trawl nets of 150 mm mesh size instead of 120 mm in the belly of the net during the summer of 2007 and 2008. These changes are especially prevalent on fishing grounds with a lot of weed, hydrozoans and bryozoans, namely ICES subarea IVb and VIIg (Belgium: Implications: Reduced benthic impact).
- There is evidence in Portugal of gillnets being fished with long soak times far beyond the national maximum time legally allowed (Portugal: Implications: Source of unaccounted mortality and increased discarding).
- Landings from the Porcupine Bank *Nephrops* fishery have been reduced in 2009. Catches have improved in late April/May but there is a predominance of females in the catches which are difficult to sell as they are “green-headed” (Ireland, France, Spain, and UK: Implications: Reduced catches in Porcupine *Nephrops* fisheries).

Development of New Fisheries

- There have been increased catches of John Dory in Area VIIb-k in recent years and this species is now widespread and abundant all over the grounds. Catches of up to 300kg per haul have been recorded with vessels consistently landing 100kg–150kg of John Dory consistently per trip (Ireland: Implications: Increased John Dory catches).
- A new *Nephrops* fishery using pots has developed in the Bay of Bisacy by up to 10 French vessels. These vessels are landing a live produce for the local market and catch rates are reported to be at viable levels (France: Implications: Development of new pot fishery).
- As indicated 3 French vessels and up to 8 Dutch have been converted to seining. These vessels are targeting mixed demersal species in VIIb-k (most effort in VIIg) and also species such as red mullet, gurnard and squid in VIId and IVb. These vessels are much more powerful than seine net vessels in Ireland and Scotland as they are converted vessels (beam trawlers, whitefish trawlers and one tuna purse seiner) (France and Netherlands: Implications: Targeted fishery on non-quota species).
- Trials in France with fish pots in the Bay of Biscay have been less successful. Catches have been dominated by conger eels which have a low value. Experiments with floating pots are underway to solve this problem (France: Implications: experimental fishery with pots).

- Passive fishing methods have been tested in ICES subarea IVc by Belgium vessels, mainly due to less of a restriction in kw days. There were also limited experimental trials for gill net fisheries in ICES subarea VIIf and with pots for cuttlefish in 2009 (Belgium: Implications: New fisheries with passive gears).
- The Belgium fleet have been experimenting with outrigger trawls as an alternative to beam trawls since 2006. Currently there are 5 vessels using this gear mainly in VIIf, VIIg and IVc. The catch composition with this gear is different than with beam trawls with reduced sole catches but increased ray catches (up to 50% by weight) and also *Nephrops* in certain areas. Catches of plaice are similar and overall levels of discards seem to be reduced by around 20% compared to standard beam trawls (Belgium: Implications: Use of outrigger trawl).

WGFTFB report to 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 Southern Shelf for hake, monkfish and megrim stocks.

It should be noted that the information contained in this report does not cover fully all fleets engaged in Southern Shelf fisheries; information was obtained from Ireland, Belgium, Spain (Basque Country) and France.

Fleet dynamics

- All countries have reported very low prices for fish and shellfish. Indications that prices for some species have dropped by as much as 50% on 2007 levels. Many vessels have tied up because of low prices in 2009. This is compared to 2008 when vessels tied up because of high fuel prices. Traditional Spanish and French markets are particularly depressed. Imports and the world recession are the main reasons given (All countries: Implications: Low prices leading to reduced effort).
- In 2008 due to the days and fuel used steaming to Rockall many Scottish vessels which would have targeted these grounds instead targeted west coast or North Sea grounds. A few vessels made single trips to Rockall but the returns were poor and therefore proved a disincentive to other vessels making the long journey. From 1st February 2009, however, many of these Scottish vessels have now reverted back to the Rockall grounds which has now become attractive due to the steaming and fishing time not counting against days at sea days at and because fuel costs have reduced. These vessels are targeting haddock, anglerfish and megrim, however, this could lead to a quick uptake of Rockall quotas. (Scotland: Implications: Shift of effort from Rockall (VIb) to IVa (North Sea) and vice versa and quick uptake of quotas).

- Up to 3–4 Scottish vessels have also moved from the North Sea and west of Scotland to Area VIIb-k in 2008 and 2009. These vessels are all large vessels 24 m+ and are targeting *Nephrops* at the Porcupine Bank and Labadie Banks. This is thought motivated by the fact that there aero no days at sea limitations in VIIb-k (Scotland: Implications: Shift of effort into VIIb-k).
- The decommissioning scheme introduced in Ireland in 2008 has now been completed. A total of 19,041kw and 6,818GT was removed from the fleet from the 45 vessels decommissioned under this scheme. In total Ireland has removed 72 vessels of 10,141 GT since 2005. The majority of vessels scrapped came from East and west coast ports from vessels which traditionally target *Nephrops* with uptake from the East and South East (Irish Sea/Smalls *Nephrops* fishery and beam trawl fleet) and the west coast (Aran and Porcupine *Nephrops* fisheries). Very few applications were received from the South coast which traditionally target whitefish. Much of the actual effort removed from the decommissioning scheme, however, has been partially negated through the introduction of ~25 modern second hand vessels (mostly ex-French) into the fleet and also a number of 12–18 m vessels. These have either replaced existing older, less efficient vessels, or owners who have taken advantage of 'semi-dormant' tonnage in Ireland. (Ireland: Implications: Reductions in Fleets but actual impact unknown).
- There has been a decommissioning scheme in France that has removed a number of 24 m+ whitefish vessels that targeted mixed demersal species including cod in VIIb-k. The actual amount of GT and KW that has been removed but is reported to be significant (France: Implications: Reductions in demersal fleet).
- In 2007 there were 17 boats (8 fishing units) in the Basque fleet operating with VHVO trawls targeting hake in VIIIabd. In 2009 this has been reduced to 6 boats (3 fishing units). Approximately half of the VHVO fleet has opted for decommissioning, some others were sold to other Cantabrian regions (Galicia) were they change to other fishing gears (single trawl or gillnets) (Spain: Implications: Reduction of 50% in one sector).
- There has been a widespread decommissioning scheme in Portugal mainly targeting trawlers and polyvalent vessels within the scope of the recovery plans for southern hake and *Nephrops* stocks. 17 trawlers will be decommissioned by November 2009. The scheme will reduce the coastal fleet by about 16% (Portugal: Implications: Reduction in fleet size).
- The Belgian fishing fleet numbered 102 fishing vessels in the beginning of 2008 and has now been reduced in 2009 to 98 active vessels due to 4 vessels going bankrupt (Belgium: Implications: Reduction in fleet size).
- There are now 5 Irish vessel freezing *Nephrops* on board. These vessels are all in the 20–24m/500–700hp size range. They are fishing with twin rig double bag trawls and are doing long trips of up to 14 days duration. These vessels are only retaining on board large grade *Nephrops* (0–10 count per kg) as well as monkfish tails and headed cod. No other catch is retained on board including species such as haddock,

flatfish, hake and John Dory. These vessels do however fish with 100mm codends so discarding of *Nephrops* is slightly reduced due to increased selectivity. A further 6 vessels are currently being fitted out with freezing systems (Ireland: Increased effort and discarding of marketable fish).

- There are 3 French vessels and approximately 10 Dutch vessels (with a further 3 under construction) that have switched to Scottish seining. These vessels are around 24m+/650hp–1200hp. The French vessels have reportedly been targeting whiting in particular but also cod and non-quota species in Area VIIb-k (mainly VIIg) for the 1st and 2nd quarter of 2009. These vessels, along with the Dutch vessels are also working in VIId and IVb for non-quota species such as red mullet, squid and gurnard. They are fishing with ~50mm diameter seine rope and are hauling the last two coils of the "ring" at 5 knots compared to 1–1.5 knots by Scottish and Irish seiners. These vessels can complete up to 8–10 rings in a day compared to 5 or 6 by Scottish and Irish vessels. This represents a considerable increase in effort in this fishery. (France and Netherlands: Implications: Increased effort in VIIb-k whitefish fisheries).
- Mainly due to the high fuel price in 2008 the owners of several larger Belgium beam trawlers went bankrupt. This coupled with the fact that the high cost of fuel meant a number of vessels did not travel to the Celtic Sea. This reduced effort by this fleet by about 30–40% in this area and particularly in the period after the Trevose Head seasonal closure was re-opened at the beginning of May. Traditionally these vessels concentrate efforts in the Celtic Sea. During 2007/2008 5% of the Belgium beam trawl fleet was removed through decommissioning. (Belgium: Implications: Reductions in Fleets but actual impact unknown).
- Fewer Belgium beam trawlers have fished in the ICES-zone VIII (Gulf of Gascogne) in 2008 and 2009, mainly due to high fuel costs in 2008 and a lack of quota. The vessels have tended to stay in the North Sea (Belgium: Implications: Shift of effort from VIII to IV).
- During quarter 4 of 2008 there was a considerable increase in effort on the *Nephrops* fishery at the back of the Aran Islands off Galway in Area VIIb with up to 40 vessels participating in the fishery for a period of 3–4 weeks. High landings of mostly "tails" were recorded during this period. These boats shifted from the Porcupine, Smalls and Labadie fisheries during this time (Ireland: Implications: Shift in effort from different *Nephrops* fisheries into Area VIIb).
- There have been a number of effort shifts in the French fleet over the period 2008/2009. Due to the anchovy ban, low prices for tuna and concerns over the sea bass fishery, a number of vessels have switched form pair trawling (~10 pairs) to bottom trawling for monkfish, megrim and *Nephrops* in the Bay of Biscay VIIIa / VIIIb. There has also been shift by a few vessels from bluefin tuna purse seining to bottom trawling or Danish seining in the Bay of Biscay VIIIa / VIIIb (3 vessels in total). During 2008 due to high fuel costs there was also as shift from *Nephrop*s twin trawling to single rig trawling by a large number

of smaller trawlers in the Bay of Biscay VIIIa / VIIIb (France: Implications: Shifts in effort into a number of fisheries).

- Two Belgium beam trawlers converted to scallop dredging in 2008, although 1 of these vessels has since reverted back to beam trawling due crew problems (Belgium: Implications: Shift from beam trawling to scallop dredging).
- The high price of fuel and the low price of the fish in 2008 has led to a reduction of fishing effort by the Basque trawling fleet The boats opted to tie-up for longer periods than in previous years during the summer months (Q3) (Spain: Implications: Reduced effort).
- Some minor changes of effort in 2007/2008 have been noted in the Basque trawl fleet from VIa to VIIIab, due to reduction of blue ling quota and from VIIIab to VIa in 2008/2009 due to better catches of anglerfish, megrim and hake (Spain: Implications: Shifts in effort from VIa to VIIIab).
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- There has been a shift of targeted effort of the Basque purse seining fishing fleet in ICES VIIIc from anchovy (closed fishery since 2006/2007) to mackerel with purse seines in early spring and to pole and line for bluefin tuna fishing during early summer. Again this shift in effort has been significant (Spain: Implications: Shift from anchovy to mackerel and tuna).
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- A number of vessels have started to use trawls with Dyneema headlines of 10–12 mm. This has reduced the overall drag of their gear and is motivated by high fuel costs in 2008. One seine net vessel reports a reduction in fuel consumption of around 400 litres per day fishing (Ireland; Implications: Improved fuel efficiency).

- There has been an increase in the use of double bag trawls in the *Nephrops* fisheries in VIIb-k. These nets have a wide bosom section and are very effective at catching *Nephrops* (Ireland: Implications: increased catching efficiency).
- A large number of French bottom trawlers in the Gulf of Lyon have significantly reduce their trawl size by up to 20% or shifting from single rig trawling to small twin trawling to reduce fuel costs (France: Implications: Improved fuel efficiency).
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- Belgium beam trawlers are increasingly being equipped with 3D mapping sonar which has opened up new areas to fishing close to wrecks and areas of hard ground (Belgium: Implications: Increased access to unfished areas).
- A few old side trawling vessels (between 10% and 20% of the Basque trawl fleet) have been replaced by new stern trawlers in the period 2007–2009. In fact since 2000 most of the trawler and longliner fleet has been renewed (Spain: Implications: newer, more efficient vessels).
- In the Basque fleet there has been a recent introduction of vacuum pumps to handle fish in the purse seine fishery for mackerel in VIIIc. This mainly to optimize fish handling and reduce processing time at sea. One of the main aims of the technological creep has been the improvement of safety and comfort of the crew. No estimation on catchability has been carried out so far although the main proven effect is the reduction in the time spent to handle the catch and subsequently the haul duration. Triplex haulers have also been fully implemented in the purse seine and pole and line fleet segment in VIIIc . Net clearers have been implemented in an important number in the coastal gillnetters (artisanal fleet) in VIIIc (Spain: Implications: New technologies increasing efficiency at sea).

Technical Conservation Measures

- A number of the larger *Nephrops* vessels (5–6 vessels) fishing on the Labadie and Jones Bank have begun to use 100 mm codends both north and south of the 51°N line and in an effort to reduce catches of small *Nephrops* (Ireland: Improved Selectivity).
- There are around 12 vessels working under a special permit scheme operated in Ireland which allows them extra monkfish quota but limits catches of certain other species including *Nephrops*. Participants must also stop all whitefish and pelagic fishing activity for a period of 28 days in the months June to September although they can fish for albacore tuna. There are reported to be up to 5–6 of these vessels tar-

geting monkfish with codend mesh sizes of > 120 mm mesh size (Ireland: Implications: reduced discarding).

- French vessels working in the Bay of Biscay VIIIa & VIIIb have been using a combination of increasing mesh size from 70 to 80 mm; using drop out panels on the bottom sheet of the extension of the trawl (Square mesh with 60 mm bar size) or using flexible *Nephrops* grid with 13 mm bar spacing. Trials have shown a reduction of *Nephrops* discards (below 9 cm total length) of 35% for the 13mm grid, 30% for 80mm, 25% for square mesh drop out panel. The use of these devices is voluntary (France: Implications: Improved selectivity).
- French vessels have been allowed to use a 70 mm mesh size in the Hake Box in the Bay of Biscay instead of 100 mm, if they use a 100mm square mesh panel in the top of the baitings. This is based on trials carried out by IFREMER in conjunction with the French industry which showed a reduction of hake discards (below 27 cm) of 25%. This modification has been allowed since 2008 with a large uptake (France: Implications: Use of TCM as an alternative to larger mesh size codend).
- There has been voluntary use of 100 mm square mesh panels by Basque vessels aimed at reducing the level of discards on the trawl fishery targeting mixed demersal species in some areas of ICES VIIIabd close to the French coast. No assessment of the impact of this has been carried out (Spain: Implications: Possible improvements in selectivity).
- There has been a reduction of the quota and increase of the MLS for bluefin tuna in pole and line fishery to 8 kg and in recreational fishery to 30 kg. For 2009 and pole and line fishery targeting bluefin tuna fishery will be closed until 15 June. These regulations are having an impact on the Basque fleet as options for these vessels are now very limited due to closure of the anchovy fishery (Spain: Implications: Increased regulations to protect tuna).
- A number of BRDs have been tested to mitigate discards in crustacean trawling (project NECESSITY, national project MARE) in Portugal. These include a sorting grid system to exclude fish by-catch; a second one to sort out immature *Nephrops*; and also a square mesh codend. No uptake by industry has been observed (Portugal: Implications: Testing of selectivity devices).
- Effort in the deepwater gillnet fisheries for hake has remained very high in 2009, particularly in the south-west Porcupine area. Changes to the regulations allowing the use of 100 mm mesh size but with a reduced net lengths and reduced effort do not seem to be working as effort seems to have increased from 2008. There has been increased monitoring of these vessels by the Irish Naval Service and one vessel recently arrested was found to have nearly 1 tonne of hake roe on board in addition to the hake catch of more than 18 tonnes. The majority of hake being retained are small fish in the 0–500g or 500–1kg size grade. (Ireland: Implications: Reduced selectivity through the use of small mesh size).
- As in 2007, Irish vessels are now discarding 0–500g and 500–1kg monkfish to meet quota restrictions. This discarding is reportedly at

quite a high level, particularly in around 200m–400m on the Achill grounds and Stanton Banks. As reported, however, some of these vessels are now using large mesh codends to reduce discarding (Ireland: Implications: High discarding).

- The producers' organisation In Belgium has set up a working group of ship owners to test gear modifications to beam trawls. The testing is partial funded nationally and partially voluntary testing. Gear modifications tested include a square mesh panel in the upper-aft of the trawl and bigger diamond meshes in the top panel. Both modifications have been tested in the Central North Sea in 2009 to reduce the by-catch of unwanted roundfish, particularly whiting and cod. Beam trawler (1200hp) fishing in the Irish Sea is using a combination of T90-codend, benthos release panel, big meshes in the top panel and roller gear. These modifications have been tested in 2006 on a project scale and are now used by the same vessel on voluntary basis (Belgium: Implications: Voluntary adoption of TCMs).

Ecosystem Effects

- There is a high abundance of hake in and around the 200 m line in Area VIa, mainly outside the French Line although hake seem to be widespread. Catches of up to 1–2 tonnes of marketable fish (mainly 1-2kg and 3–5kg grade fish) have been reported consistently since March by Irish and Scottish vessels working in Area VIa. However, due to low market prices there has been high discarding of hake below 40 cm. (Ireland and Scotland: Implication: Increased abundance of hake).
- Boats entering the Trevose closed area in Area VIIg, statistical rectangle 32E3 had very poor catches when this box re-opened. There seem to be an abundance of lesser spotted dogfish. Catches did improve after the box was re-opened (Ireland: Implications: effectiveness of closed area).
- Monkfish catches in the Rockall fishery Area VIb were reported to be increased in Q1 and Q2 of 2009. Fish seem to be abundant with catches of up to 1 tonne from some hauls. (Ireland: Increased abundance of monkfish in Area VIb).
- IFREMER in France along with the industry are continuing to do extensive testing of acoustic deterrent devices in French pelagic and gillnet fisheries. The results have been mixed but reductions in cetacean bycatch of between 40–60% have been observed in the bass fishery (France: Implications: Reduction in cetacean bycatch).
- There has not been a major shift in mesh size categories (anecdotic information) although some of the Belgian beam trawler fleet have been fishing with trawl nets of 150 mm mesh size instead of 120 mm in the belly of the net during the summer of 2007 and 2008. These changes are especially prevalent on fishing grounds with a lot of weed, hydrozoans and bryozoans, namely ICES subarea IVb and VIIg (Belgium: Implications: Reduced benthic impact).
- There is evidence in Portugal of gillnets being fished with long soak times far beyond the national maximum time legally allowed (Portu-

gal: Implications: Source of unaccounted mortality and increased discarding).

- Landings from the Porcupine Bank *Nephrops* fishery have been reduced in 2009. Catches have improved in late April/May but there is a predominance of females in the catches which are difficult to sell as they are "green-headed" (Ireland, France, Spain, and UK: Implications: Reduced catches in Porcupine *Nephrops* fisheries).

Development of New Fisheries

- There have been increased catches of John Dory in Area VIIb-k in recent years and this species is now widespread and abundant all over the grounds. Catches of up to 300 kg per haul have been recorded with vessels consistently landing 100kg–150kg of John Dory consistently per trip (Ireland: Implications: Increased John Dory catches).
- A new *Nephrops* fishery using pots has developed in the Bay of Biscay by up to 10 French vessels. These vessels are landing a live produce for the local market and catch rates are reported to be at viable levels (France: Implications: Development of new pot fishery).
- As indicated 3 French vessels and up to 8 Dutch have been converted to seining. These vessels are targeting mixed demersal species in VIIb-k (most effort in VIIg) and also species such as red mullet, gurnard and squid in VIId and IVb. These vessels are much more powerful than seine net vessels in Ireland and Scotland as they are converted vessels (beam trawlers, whitefish trawlers and one tuna purse seiner) (France and Netherlands: Implications: Targeted fishery on non-quota species).
- Trials in France with fish pots in the Bay of Biscay have been less successful. Catches have been dominated by conger eels which have a low value. Experiments with floating pots are underway to solve this problem (France: Implications: experimental fishery with pots).
- The Belgium fleet have been experimenting with outrigger trawls as an alternative to beam trawls since 2006. Currently there are 5 vessels using this gear mainly in VIIf, VIIg and IVc. The catch composition with this gear is different than with beam trawls with reduced sole catches but increased ray catches (up to 50% by weight) and also *Nephrops* in certain areas. Catches of plaice are similar and overall levels of discards seem to be reduced by around 20% compared to standard beam trawls (Belgium: Implications: Use of outrigger trawl).

WGFTFB 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, France, Belgium, Netherlands, Sweden and Norway. Only very limited information was received from the UK-England and Wales or Denmark.

Fleet dynamics

- All countries have reported very low prices for fish and shellfish. Indications that prices for some species have dropped by as much as 50% on 2007 levels. Many vessels have tied up because of low prices in 2009. This is compared to 2008 when vessels tied up because of high fuel prices. Traditional Spanish and French markets are particularly depressed. Imports and the world recession are the main reasons given (All countries: Implications: Low prices leading to reduced effort).
- In 2008 due to the days and fuel used steaming to Rockall many Scottish vessels which would have targeted these grounds instead targeted west coast or North Sea grounds. A few vessels made single trips to Rockall but the returns were poor and therefore proved a disincentive to other vessels making the long journey. From 1 February 2009, however, many of these Scottish vessels have now reverted back to the Rockall grounds which has now become attractive due to the steaming and fishing time not counting against days at sea days at and because fuel costs have reduced. These vessels are targeting haddock, anglerfish and megrim, however, this could lead to a quick uptake of Rockall quotas. (Scotland: Implications: Shift of effort from Rockall (VIb) to IVa (North Sea) and vice versa and quick uptake of quotas).
- Up to 3–4 Scottish vessels have also moved from the North Sea and west of Scotland to Area VIIb-k in 2008 and 2009. These vessels are all large vessels 24m+ and are targeting *Nephrops* at the Porcupine Bank and Labadie Banks. This is thought motivated by the fact that there area no days at sea limitations in VIIb-k (Scotland: Implications: Shift of effort into VIIb-k)
- Due to the new by-catch limits (30%) introduced from February 2009 as part of the new technical measures in Area VIa, the west coast grounds, inside the 200 m line, are effectively closed to Scottish vessels, with whitefish vessels fishing outside the 200 m line or shifting to North Sea grounds. The effort shift associated with this is expected to be large (Scotland: Implications: Shift in effort from VIa inside the French Line to Area VIa and IVa).
- The codend mesh size for smaller vessels (< 15m) on west coast grounds has increased from 100 mm to 110 mm. As a result some (>20 Scottish vessels) of those which targeted megrim have moved to other areas, particularly the North Sea as these vessels are too small to target Rockall. (Scotland: Implications: Shift of effort from Area VIa into other areas).
- The new regulations in Area VIa have also affected Scottish Seine net vessels, which are now on a one net rule and have to use the whitefish codend mesh size of 120 mm. This has effectively closed the fishery

for these vessels and forced them to tie up or shift into the North Sea. (Scotland: Implications: Shift of effort from Area VIa to other areas).

- There has been a decommissioning scheme in France that has removed a number of 24m+ whitefish vessels that targeted mixed demersal species including cod in VIIb-k and the fisheries in VIId. The actual amount of GT and KW that has been removed but is reported to be significant (France: Implications: Reductions in demersal fleet).
- Since 2008, 24 boats out of 320 boats were decommissioned from the Dutch beam trawl fleet (7.5% reduction). A number of these vessels have been subsequently using passive licences. There is a tendency to opt for smaller multi-purpose vessels replacing the conventional beam trawler (Dutch: Implications: Reduction in effort in the beam trawl sector).
- There has been decommissioning of Swedish Baltic/Kattegat cod trawlers during 2008/2009 both old and newer vessels have been removed from the fleet - 10% in numbers, 15% in capacity. This has been driven by low quotas for cod, new days at sea regs and low prices (Sweden: Implications: Reduced fleet numbers).
- The Belgian fishing fleet numbered 102 fishing vessels in the beginning of 2008 and has now been reduced in 2009 to 98 active vessels due to 4 vessels going bankrupt (Belgium: Implications: Reduction in fleet size).
- There are 3 French vessels and approximately 10 Dutch vessels (with a further 3 under construction) that have switched to Scottish seining. These vessels are around 24m+/650hp-1200hp. The French vessels have reportedly been targeting whiting in particular but also cod and non-quota species in Area VIIb-k (mainly VIIg) for the 1st and 2nd quarter of 2009. These vessels, along with the Dutch vessels are also working in VIId and IVb for non-quota species such as red mullet, squid and gurnard. They are fishing with ~50mm diameter seine rope and are hauling the last two coils of the "ring" at 5 knots compared to 1–1.5 knots by Scottish and Irish seiners. These vessels can complete up to 8-10 rings in a day compared to 5 or 6 by Scottish and Irish vessels. This represents a considerable increase in effort in this fishery. (France and Netherlands: Implications: Increased effort in VIIb-k whitefish fisheries).
- Mainly due to the high fuel price in 2008 the owners of several larger Belgium beam trawlers went bankrupt. This coupled with the fact that the high cost of fuel meant a number of vessels did not travel to the Celtic Sea. This reduced effort by this fleet by about 30–40% in this area and particularly in the period after the Trevose Head seasonal closure was re-opened at the beginning of May. Traditionally these vessels concentrate efforts in the Celtic Sea. During 2007/2008 5% of the Belgium beam trawl fleet was removed through decommissioning. (Belgium: Implications: Reductions in Fleets but actual impact unknown).
- Fewer Belgium beam trawlers have fished in the ICES-zone VIII (Gulf of Gascogne) in 2008 and 2009, mainly due to high fuel costs in 2008

and a lack of quota. The vessels have tended to stay in the North Sea (Belgium: Implications: Shift of effort from VIII to IV).

- Two Belgium beam trawlers converted to scallop dredging in 2008, although 1 of these vessels has since reverted back to beam trawling due crew problems (Belgium: Implications: Shift from beam trawling to scallop dredging).
- In 2007 there were more or less as many Belgium beam trawlers changing between flatfish and shrimp beam trawl fisheries as in 2006. However, due to reduced landings in 2007 landings of brown shrimp (*Crangon crangon*), effort was reduced quite significantly. In the second half of 2008, the landings of shrimp have increased again and effort by beam trawlers has increased in this fishery (Belgium; Implications: Fluctuating effort in the *Crangon* fishery).
- In the Dutch fleet the gradual shift from beam trawling on flatfish to twin trawling on other species e.g. gurnards, and *Nephrops*, etc. has continued in 2008 and 2009. A number of beam trawlers decided to shift to other techniques such as outrigging or Scottish seining in the British Channel (VIId). The recent drop in fish prices, however, has caused a temporary halt in the use of alternative lower drag gears. Some went back to normal beam trawling to catch remaining sole quota in 2008 e.g. the vessels using outriggers (Netherlands: Implications: Shifts in effort from beam trawling).
- In Belgium there up to 3 vessels now using trammel nets for sole, pots for cuttlefish, Handlining for bass and tangle nets for turbot, mainly in IVc, VIIe and VIIf. There is considerable interest in Belgium for diversifying into these gears although there is an issue with days at sea as Belgium as only a very small allocation for static nets. Fishermen in the Netherlands are also considering shifting to these gears (Belgium: Implications: Diversification into static gears).
- Following introduction of the new days at regime ~70 Swedish vessels have received exemption in the Kattegat for using grids in the *Nephrops* fishery. This device reduces cod catches to almost zero levels (Sweden: Implications: Reduced cod catch).
- In the first quarter of 2008, the number of Swedish vessels fishing (and effort deployed) in the Kattegatt decreased due to an increased effort cost (2.5 days at sea per effort day deployed). This effort was mainly been reallocated to the Skagerrak or the Baltic Sea. Vessels without the possibility to change area mainly targeted *Nephrops* using grid-equipped trawls (i.e. a gear with effort limitation). (Sweden: Implications: Shifts in effort among areas and fleets).
- There has been a gradual shift towards *Nephrops* and *Pandalus* fisheries from traditional demersal fish during the last years. This shift is due to lowered quotas per vessel for cod (Area IIIa) (Sweden: Implications: Shift away from cod fisheries).
- Several larger French trawlers using mesh size range 70–99 mm have moved further north in the North sea (south east 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).

- French trawlers using 70–99 mm fishing in VIId and IVb have increasingly targeted red mullet, sea bass and squids to offset lower catches of cod, whiting and plaice). Other vessels including Dutch and Belgium beam trawlers and Dutch seiners are also targeting these species at high effort levels (France: Implications: Targeting of different non-quota species).
- There has been a significant decrease in effort in the North Sea in 2008/2009 by Northern Irish vessels. Many vessels stayed in the Irish Sea due to high fuel prices and also in 2009 due to uncertainty about the days at sea allocations. (Northern Ireland Implications: Increased effort in VIIa).

Technology Creep

- 3 Scottish seiners are now fitted with seine power reels that allow them to haul without using a seine winch. This considerably increases the efficiency of the operation and allows an extra haul per day. These vessels are currently working in the North Sea but this could spread to the west of Scotland at a later date. Most of the French seiners working in VIIb-k are also using this system (Scotland ad France: Implications: Improved efficiency in seine net fisheries).
- Some Dutch vessels started using the SumWing construction replacing conventional beam trawls with trawl shoes. A comparative fishing experiment showed no effect on target and non-target species and an 11% lower fuel consumption. The new design was first used on even grounds in the Northern North Sea, and trials on harder grounds are foreseen in the near future. Tests are being done with hydro-dynamical stimulation (HydroRig) and replacement of beam trawls by Outrigger nets. These are to be continued in 2009. Five beam trawlers will be converted to fishing with pulse trawls. The first one has currently started testing the system and it maybe combined with the SumWing technology (Netherlands: Implications: More efficient beam trawls).
- In 2009 more and more Belgium beam trawlers are using roller gear instead of the standard trawl shoes to reduce fuel consumption. About 3 vessels are also investigating the Dutch sumwing beam trawl to reduce fuel consumption as well. It is expected that this initiative will lead to gear modifications used in beam trawls, depending on legislation changes (Belgium: Implications: Adoption of fuel efficient gear).
- Belgium beam trawlers and French trawlers are increasingly being equipped with 3D mapping sonar which has opened up new areas to fishing close to wrecks and areas of hard ground (Belgium and France: Implications: Increased access to unfished areas).
- The move by Belgium beam trawlers to use R-nets and chain matrices rather than with V-nets, using tickler chains has continued in 2008 and 2009. Fishing speed for beam trawls with R-nets is generally lower and to high fuel prices in 2008 fewer beam trawlers now use the V-nets. The impact of this change on benthos and discarding has not

been assessed but is anticipated to have reduced (Belgium: Implications: Unknown).

Technical Conservation Measures

- For vessels in the new Scottish Conservation Credit Scheme the minimum SMP mesh sizes for *Nephrops* vessels from 1 February 2009 are 120 mm @ 12–15 m for west of Scotland grounds (VIa) and 110mm in North Sea grounds (IVa). The use of this gear is now mandatory under the Conservation Credit Scheme. It has been estimated that the 120 mm SMP gives a 30% increase in L50 of haddock, whiting and saithe. Smaller increase in L50 of perhaps 10% for cod are likely but only if the panel is put close to the codend (Scotland: Implications: Improved selectivity).
- Offshore *Nephrops* vessels are making up their days from a combination of *Nephrops* and whitefish but using the same 100 mm codend to for both in the North Sea. The reason for this is down to the uncertainty at the start of each fishing trip on how the fish by-catch (>35% of the catch must be *Nephrops*) will work out. Therefore vessels leave port with 100 mm codends with lifting bags rigged. If fish are the main component then the rearmost meshes attaching the bag to the codend are cut (i.e. removing the lifting bag) and the vessel is now targeting fish for the trip(Scotland: Implications: Mis-reporting).
- For Scottish vessels in the Scottish Conservation Credit Scheme the minimum SMP mesh sizes for *Nephrops* vessels from 1 February 2009 are 120 mm @ 12–15 m for west of Scotland grounds and 110 mm in North Sea grounds. The impact of this unknown but it is expected to improve the selectivity for haddock and whiting but only slightly for small cod (Scotland: Implications: Improved selectivity).
- There have been a number of attempts in Scotland to develop cod avoidance gears that maintain catches of haddock and whiting as well as other species such as monkfish, megrim and lemon sole. These trials have looked at incorporating large mesh panels (800 mm) into the belly sheets of standard trawl designs. The results are still being analysed but indicate that cod catches can be reduced but not eliminated (Scotland: Implications: Low cod impact gears).
- Scottish seine net vessels are now restricted to a one net rule and have to use the whitefish mesh size of 120 mm. This has created difficulties for these vessels with a result many are considering changing over to pair seine gear were the impact is lessened (Scotland: Implications: Improved selectivity of seine net vessels).
- The use of Bycatch Reduction Panels (BRP) in the lower sheet of beam trawls is studied on FRV "Tridens", with voluntary uptake by several Dutch beam trawlers. Some twin-trawlers are also using a similar BRP in the top sheet. Indications are that plaice discards can be dropped by 20% (Netherlands: Implications: Voluntary use of TCMs and reduced discarding).
- The producers' organisation In Belgium has set up a working group of ship owners to test gear modifications to beam trawls. The testing is partial funded nationally and partially voluntary testing. Gear modifications tested include a square mesh panel in the upper-aft of

the trawl and bigger diamond meshes in the top panel. Both modifications have been tested in the Central North Sea in 2009 to reduce the by-catch of unwanted roundfish, particularly whiting and cod. Beam trawler (1200hp) fishing in the Irish Sea is using a combination of T90-codend, benthos release panel, big meshes in the top panel and roller gear. These modifications have been tested in 2006 on a project scale and are now used by the same vessel on voluntary basis (Belgium: Implications: Voluntary adoption of TCMs).

- In Norway there has been extensive testing by industry of pelagic and semipelagic trawling for saithe in the North Sea. Three trawlers have been involved in 2008/2009. Until 2008, only demersal trawl was used. It is expected that the number of vessels using this technique will increase in 2009. During semipelagic trawling the doors are off the seabed and the opening (27 by 70 m) of the new trawls are approximately 20 times the size of commercial twin trawls for gadoids. According to information from the fishermen the fuel/kg saithe caught, are reduced. Another reason for trying this technique is the focus on the impact of trawl doors on the seabed (Norway: Implications: Unknown).
- Altogether ~140–150 Swedish *Nephrops* vessels are now either fishing with the grid or intend to start fishing with it due to days at sea exemptions (Sweden: Implications: Widespread uptake of selective gear).
- A new closed area regime was introduced in the Kattegat in 2009 to protect Kattegat cod. Among other measures four different zones for gear usage were introduced whereby both the Swedish grid and a Danish SELTRA-trawl (>300 mm SMP in the codend top panel) are mandatory in a large part of the area. The driver for this is access to otherwise closed areas (the Kattegatt closure, Swedish coastal waters). Exclusion from the kW-day system for Swedish vessels using the *Nephrops* grid and square mesh codend (Sweden and Denmark: Implications: Access to areas for use with selective gears).

Ecosystem Effects

- All countries report that the increase in the cod quota for the North Sea in 2009 does not adequately reflect the amount of fish in the stock currently. The result predicted is discarding of cod and this has been strongly signalled to the Commission by the NSRAC (All countries: Implications: Discarding of cod).
- There is anecdotal evidence in both Scotland and Belgium that the ban of high grading introduced into the North Sea under the TAC and quota regulations for 2009 is not working. There are reports fishermen are ignoring these regulations and discarding large quantities of small grade cod due to the quota being very limiting (Scotland and Belgium: Implications: High grading ban).
- There is anecdotal evidence in Scotland that the real-time closures are being more widely respected by Scottish vessels with the number of closures in operation increasing to over 55 closures already in 2009. There has been no assessment of the impact of these closures but as the numbers of small cod in the North Sea has increased it is hoped

these closures will protect this part of the stock (Scotland: Implications: Real-time closures).

- There are problems in the UK with the uptake of the whiting, saithe and cod quotas. The whiting quota was almost 50% taken by April 2009, with the saithe and cod quotas around 40% caught. It is anticipated this will lead to further discarding of these species later in the year. The fishermen claim whiting particularly are very abundant in the North Sea this year (UK: Implications: Increased discarding).
- There has not been a major shift in mesh size categories (anecdotic information) although some of the Belgian beam trawler fleet have been fishing with trawl nets of 150 mm mesh size instead of 120 mm in the belly of the net during the summer of 2007 and 2008. These changes are especially prevalent on fishing grounds with a lot of weed, hydrozoans and bryozoans, namely ICES subarea IVb and VIIg (Belgium: Implications: Reduced benthic impact).
- Five beam trawlers will be converted to fishing with pulse trawls. The first one has currently started testing the system (Netherlands: Implications: Unknown).
- The beam trawl fleet in both Netherlands and Belgium are feeling the increased pressure of the market not wanting to buy fish caught with beam trawls due to the bad reputation. This incentive is stimulating research on selective nets and ways of diminishing impact. Initiatives have been taken to promote fish products from ecosystem friendly methods, e.g. outriggers. In the UK the Seafish Responsible Fishing Scheme is being used in a similar way but up to 300 UK vessels to promote their catch. These initiatives are likely to continue over the next few years (All Countries: Implications: Better public perception).
- The Dutch beam trawl fleet are voluntarily using longitudinal release holes and benthic release panels made of square mesh in the lower panel of the trawl, which open when nets fill with benthos. Research is being carried out with the industry to optimise a Benthic Release Panel for the Dutch beam trawling segment. This work is continuing in 2009 (Netherlands: Implications: Reduced impact on benthos).
- Poor prices for *Nephrops* are affecting all fleets targeting this species. Prices have dropped up to 40% from 2007/2008 levels for both whole, tails and frozen *Nephrops.* Despite low prices effort has remained high on this species as many fishermen face have few options (All countries: Implications: Increased effort in *Nephrops* fisheries).

Development of New Fisheries

- There have been increased catches of John Dory in Area VIIb-k in recent years and this species is now widespread and abundant all over the grounds. Catches of up to 300 kg per haul have been recorded with vessels consistently landing 100kg–150kg of John Dory consistently per trip (Ireland: Implications: Increased John Dory catches).
- As indicated 3 French vessels and up to 10 Dutch have been converted to seining. These vessels are targeting mixed demersal species in VIIb-k (most effort in VIIg) and also species such as red mullet, gurnard and squid in VIId and IVb. These vessels are much more powerful than seine net vessels in Ireland and Scotland as they are

converted vessels (beam trawlers, whitefish trawlers and one tuna purse seiner) (France and Netherlands: Implications: Targeted fishery on non-quota species).

- Passive fishing methods have been tested in ICES subarea IVc by Belgium vessels, mainly due to less of a restriction in kw days. There were also limited experimental trials for gill net fisheries in ICES subarea VIIf and with pots for cuttlefish in 2009 (Belgium: Implications: New fisheries with passive gears).
- The Belgium fleet have been experimenting with outrigger trawls as an alternative to beam trawls since 2006. Currently there are 5 vessels using this gear mainly in VIIf, VIIg and IVc. The catch composition with this gear is different than with beam trawls with reduced sole catches but increased ray catches (up to 50% by weight) and also *Nephrops* in certain areas. Catches of plaice are similar and overall levels of discards seem to be reduced by around 20% compared to standard beam trawls (Belgium: Implications: Use of outrigger trawl).

WGFTFB report to WGBFAS

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 limited information recent changes on fleet dynamics, technical conservation measures, ecosystem effects and new fisheries in the Baltic Sea and Kattegat. No other relevant information was given.

It should be noted that the information contained in this report does not cover fully all fleets engaged in the Baltic; information was obtained from Sweden and Germany only.

Fleet dynamics

- In the first quarter of 2008, the number of Swedish vessels fishing (and effort deployed) in the Kattegatt decreased due to an increased effort cost (2.5 days at sea per effort day deployed). This effort was mainly been reallocated to the Skagerrak or the Baltic Sea. Vessels without the possibility to change area mainly targeted *Nephrops* using grid-equipped trawls (i.e. a gear with effort limitation). (Sweden: Implications: Shifts in effort among areas and fleets).
- There has been a gradual shift towards *Nephrops* and *Pandalus* fisheries from traditional demersal fish during the last years. This shift is due to lowered quotas per vessel for cod (Area IIIa) (Sweden: Implications: Shift away from cod fisheries).
- There has been decommissioning of Swedish Baltic/Kattegat cod trawlers during 2008/2009 both old and newer vessels have been removed from the fleet - 10% in numbers, 15% in capacity. This has been driven by low quotas for cod, new days at sea regulations and low prices (Sweden: Implications: Reduced fleet numbers).

Technology Creep

- No information on technology creep was reported.

Technical Conservation Measures

- A new closed area regime was introduced in the Kattegat in 2009 to protect Kattegat cod. Among other measures four different zones for gear usage were introduced whereby both the Swedish grid and a Danish SELTRA-trawl (>300 mm SMP in the codend top panel) are mandatory in a large part of the area. The driver for this is access to otherwise closed areas (the Kattegatt closure, Swedish coastal waters). Exclusion from the kW-day system for Swedish vessels using the *Nephrops* grid and square mesh codend. This closure is expected to shift effort by Swedish and Danish vessels into other areas e.g. Baltic (Sweden and Denmark: Implications: Access to areas for use with selective gears).
- There has been extensive testing of T90, Bacoma windows and Dyneema codends by German in response to the regulations regarding the use of T90 and Bacoma windows. These trials have been conducted in 2008 and the most interesting finding was with the use of Dyneema as a codend material. These trials have shown codends constructed in Dyneema in either conventional diamond mesh and T90 to be very selective (Germany: Implications: Improvements in selectivity for cod).
- There have been experiments in Germany with a "topless" trawl to conduct a clean flounder fishery in the Baltic Sea. Reductions in cod have been achieved but with corresponding reductions in flounder catches (Germany: Implications: Clean flatfish fishery).

Ecosystem Effects

- A new long range acoustic deterrent device has been developed by Germany and Denmark. The device has a detection distance of 400m and is now being used by the Danish and German authorities to monitor pinger usage in the Baltic. Since the adoption of this device several Russian gillnet vessels have been warned over failure to use pingers, which are compulsory in the Baltic to protect harbour porpoises (Germany: Implications: Monitoring of acoustic deterrent devices).
- Tests have been carried out in German with plate groundgear, similar to the groundgear developed in Norway. Initial tests were not successfully, although the gear has subsequently been modified to include roller bobbins in between the plates. Is was found to work well in terms of fuel efficiency and reportedly with reduced bottom impact, although no quantification of this reduction in impact was carried out (Germany: Implications: Testing of low impact bottom trawls).

Development of New Fisheries

- There has been limited testing of pots to target cod in the Baltic Sea by Germany. The results, however, have been very disappointing with very low catch rates and this work has been abandoned (Germany: Implications: Testing of alternative gears).

WGFTFB report to WGWIDE, HAWG, WGNEW & 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, Spain (Basque Country), Norway, Faroe Islands and France.

Fleet dynamics

- The Faroes and Iceland have unilaterally declared mackerel quotas in the NE Atlantic. This amounts to increased effort on the mackerel stock and may jeopardise attempts at developing a long term management plan for NE Atlantic mackerel (Iceland & Faroes: Implications: Increased effort).
- This has led in the Faroe Islands there to continued and sustained renewal of large combined pelagic trawl and purse seine vessels and this has resulted in increased onboard processing capacity for pelagic species including blue whiting, herring, mackerel and capelin and the movement of effort away from demersal fisheries (Faroe Islands: Implications: Increased effort into pelagic fisheries).
- There has been a shift of targeted effort of the Basque purse seining fishing fleet in ICES VIIIc from anchovy (closed fishery since 2006/2007) to mackerel with purse seines in early spring and to pole and line for bluefin tuna fishing during early summer. Again this shift in effort has been significant (Spain: Implications: Shift from anchovy to mackerel and tuna).
- The Irish RSW fleet agreed voluntarily that only a selection of vessel (approx 12) would target the reduced blue whiting quota with specific allocations and those that opted out would have an opportunity in 2009 (Ireland: Implications: Voluntary management scheme).
- Up to 6 of the Irish RSW Fleet participated in the Albacore tuna fishery in 2008. This fishery was very successful with consistent landings and reasonable prices. It is anticipated that more of these vessels will participate in this fishery given that Ireland has 50 licences available and a quota of ~7000 tonnes that is currently not being fully caught (Ireland: Implications: Alternative opportunities for pelagic vessels).

- In Q3 of 2008 two Spanish freezer stern trawlers landed frozen graded blue whiting into Killybegs, which was transported via containers back to Spain. These 20 year old 50 m vessels generally do not focus on blue whiting and this was seen as an interesting development (Spain: Implications: Possible additional effort on blue whiting).

Technology Creep

- In the Basque fleet there has been a recent introduction of vacuum pumps to handle fish in the purse seine fishery for mackerel in VIIIc. This mainly to optimize fish handling and reduce processing time at sea. One of the main aims of the technological creep has been the improvement of safety and comfort of the crew. No estimation on catchability has been carried out so far although the main proven effect is the reduction in the time spent to handle the catch and subsequently the haul duration. Triplex haulers have also been fully implemented in the purse seine and pole and line fleet segment in VIIIc. Net clearers have been implemented in an important number in the coastal gillnetters (artisanal fleet) in VIIIc (Spain: Implications: New technologies increasing efficiency at sea).
- There has been an increase in the use of dynex warps from steel wires in the pelagic fisheries by Icelandic and Irish vessels. The use of dynex reduces drag considerably compared to traditional warps and vessels can tow faster (Iceland & Ireland: Implications: Improvements in fuel efficiency)
- There has been a concerted effort in Ireland to reduce the size of pelagic trawls being used. This is largely driven by high fuel costs but also as control and enforcement has become a lot tighter so vessels are tending to fish strictly to quota (Ireland: Implications: Smaller CPUE).

Technical Conservation Measures

- There has been a reduction of the quota and increase of the MLS for bluefin tuna in pole and line fishery to 8 kg and in recreational fishery to 30 kg. For 2009 and pole and line fishery targeting bluefin tuna fishery will be closed until 15 June. These regulations are having an impact on the Basque fleet as options for these vessels are now very limited due to closure of the anchovy fishery (Spain: Implications: Increased regulations to protect tuna).
- Experiments in the Norwegian trawl fishery for blue whiting and Norway pout along the Norwegian Trench have been carried out to reduce the by catch of saithe and to some extent haddock. Experiment performed 2008 with both flexible and rigid grid systems with 40 millimeter bar spacing have proved to reduce the by catch substantial ~90% in some cases. From 1 January 2009, the trawlers are allowed to have a maximum of 5 % mixture of saithe (by weight) in the landings of blue whiting and effectively meaning that they have to use a grid device to comply with the rules (Norway: Implications: Improved selectivity of saithe in pelagic fisheries).
- Efforts have been continuing between the Faroe Islands and Russia to introduce the flexi grid on board Russian pelagic vessels targeting blue whiting. Faroese, Norwegian and Icelandic vessels now all use

the flexi grid developed in this fishery but the Russian vessels do not currently as they say fish catch is reduced considerably. Joint trials are being conducted (Faroe Islands and Russia: Implications: Wider adoption of selectivity device).

- Observation work by Norway on pelagic trawls with specially designed collection bags research has shown that escape from the aft part of the trawl is substantial at times. Some quantification of the escape of blue whiting and herring has been made and is high (Norway: Implications: Unaccounted mortality in pelagic trawls).
- In May 2008 a first field experiment was conducted by Norway to study the mortality of herring after crowding and slipping. The experiments were carried out onboard commercial purse seine vessels in the open sea. It was shown that the mortality was dependent on the degree of crowding. Further experiments have to be done to provide reliable mortality estimates (Norway: Implications: Unaccounted mortality in purse seines).
- There is still ongoing development work into sorting grids for the pelagic vessels in Ireland and Scotland motivated by higher prices for larger grade fish and the need to reduce the catch of mackerel when targeting horse mackerel. These grids have proven to be quite effective at releasing fish if catches are < 300–400 tonnes but are less effective when catches are larger. There is still no assessment of the mortality of escaping fish that remain a drawback (Ireland and Scotland: Implications: Still unknown at present).

Ecosystem Effects

- IFREMER in France along with the industry are continuing to do extensive testing of acoustic deterrent devices in French pelagic and gillnet fisheries. The results have been mixed but reductions in cetacean bycatch of between 40–60% have been observed in the bass fishery (France: Implications: Reduction in cetacean bycatch).
- There were reports of widespread slipping of mackerel and horse mackerel in Q4 of 2008 and Q1 of 2009 by pelagic vessels from all countries. This was due to a high predominance of small mackerel on the ground with a low market value. It was also driven in Ireland by the management regime that does not allow vessels to land horse mackerel with more than 5% of mackerel bycatch. There is still no assessment of the scale of slipping in these fisheries or their likely impact (All countries: Implications: Unaccounted mortality).
- During Q1 of 2009 there have been large quantities of mackerel in Area VIa both inside and outside the French Line. All of this fish is being discarded due to quota restrictions and is reported to be on a wide scale. During trials on an Irish vessel in April catches of up to 4 tonnes per tow were recorded (Ireland: Implications: discarding of mackerel).
- Irish fishermen have reported signs of recovery in the Celtic Sea herring stock that in the last number of years was clearly in a poor state (Ireland: Implications: Improvement in Celtic Sea herring stock).
- Due to the heavy landings of mackerel ad horse mackerel into Killybegs in Q1 and Q4 of 2008 and Q1 of 2009 some vessels have been

holding fish for up to 5 days in the RSW tanks as the processors try to deal with the very large backlogs. Two vessels had to send mackerel to fishmeal as their fish spoiled due to a lack of appropriate onboard storage facilities (Ireland: Implications: Mackerel being made into fish meal).

Development of New Fisheries

- Up to 17 Icelandic pelagic trawlers that were targeting capelin before this fishery was closed have developed an experimental fishery for Pearlsides or Mullers bristlemouth (*Maurolicus muelleri*). Catches have initially been poor (> 700 tonnes in a trip) as the fish is only 4 cm. The fishing gear need to be developed further if this fishery is to continue but the motivation is high as the capelin is closed (Iceland: Implications: Development of new fishery)
- There has been increased interest in Norway in the exploitation of marine zooplankton such as copepods and krill. Several novel methods have been tested using air bubbles to lift Calanus to the sea surface to be skimmed by oil spill recovery type equipment and also by concentrating Calanus closer to the surface to be collected by a small mesh trawl with reduced opening area (Norway: Implications: Targeting of copepods and krill).
- Up to 8 Irish vessels have continued to exploit boarfish and landings in 2008 were estimated at around 10 000 tonnes at a value of over €2 million. All of the catch is being processed as fish meal as it has a very high oil content. No assessment of the potential impact of this fishery has been carried out but it has diverted effort from the blue whiting fishery for which Ireland had a much reduced quota in 2008/2009 (Ireland: Implications: Continued development of a new fishery).
- There are plans for several Irish RSW vessels to fish off the coast of Chile for horse mackerel. The licences have been applied to from the South Pacific Regional Management Organisation. This fishery takes place up to 300 miles offshore and the vessels are planning to feed into a freezer ship at sea. If this venture is successful this may reduce effort (Ireland: Implications: Unknown at present).

WGFTFB report to AFWG & 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 Iceland, Faroe Islands and Norway

Fleet dynamics

- In the Faroe Islands there has been continued and sustained renewal of large combined pelagic trawl and purse seine vessels and this has resulted in increased onboard processing capacity for pelagic species including blue whiting, herring, mackerel and capelin and the movement of effort away from demersal fisheries (Faroe Islands: Implications: Increased effort into pelagic fisheries).
- Large Faroese longline vessels have worked deeper water targeting tusk, ling and other deepsea species as a result of recent low catches and low prices of cod and haddock. The first four months in 2009 compared to 2008 Faroese landings of cod and haddock have seen a reduction in quantity of 31% and 47% percent respectively and 62% and 64% percent in value (Faroe Islands: Implications: Reduced effort on cod and haddock).
- The effort quota system (days at sea allocation) in the Faroes has resulted in decreasing number of boats in the fleet of small trawlers targeting flatfish inside 12 nautical mile zone. However, the remaining boats have been able to fish with essentially unlimited days as the allocation to this segment can sustained this level of effort with the number of vessels remaining (Faroe Islands: Implications: Unrestricted effort by smaller number of vessels).

Technology Creep

- There has been an increase in the use of dynex warps from steel wires in the cod and haddock fisheries in area Va by Icelandic vessels. The use of dynex reduces drag considerably compared to traditional warps and vessels can tow faster (Iceland: Implications: Improvements in fuel efficiency).
- Several of the existing large Faroese pair-trawlers have begun to target saithe with larger (high vertical opening) trawls as this species sometimes is found off bottom and up in the water column and not accessible by conventional bottom pair trawl. This is due to low prices for cod and haddock (Faroe Islands: Implications: Use of pelagic trawls).
- Prompted by high fuel prices one Faroese vessel experimented with Scottish seine fishing in 2008/2009. The boat had little success, as it was not fully rigged for this fishing but the experiments are expected to continue in 2009. In late 1940s to mid 1950s around 15 Faroese boats were rigged for Danish seine, but worked mainly in Icelandic waters as few suitable grounds are found on the Faroe plateau and there seems to be renewed effort in this method in Faroese given bottom impact is thought to be reduced and fuel consumption is low (Faroe Islands: Implications: Unknown).

Technical Conservation Measures

- In Iceland more than half the shrimp fleet are using extra codend with 135 mm mesh to collect fish released from the opening at the top of Nordmore grids with a bar spacing of 22 mm used in this fishery. The idea is to retain some of the fish catch in this fishery mainly due to low price for shrimp (Iceland: Implications: Retention of large fish catch in shrimp fisheries).

- Experiments in the Norwegian trawl fishery for blue whiting and Norway pout along the Norwegian Trench have been carried out to reduce the by catch of saithe and to some extent haddock. Experiment performed 2008 with both flexible and rigid grid systems with 40 millimeter bar spacing have proved to reduce the by catch substantial ~90% in some cases. From 1 January 2009, the trawlers are allowed to have a maximum of 5 % mixture of saithe (by weight) in the landings of blue whiting and effectively meaning that they have to use a grid device to comply with the rules (Norway: Implications: Improved selectivity of saithe in pelagic fisheries).
- Efforts have been continuing between the Faroe Islands and Russia to introduce the flexi grid on board Russian pelagic vessels targeting blue whiting. Faroese, Norwegian and Icelandic vessels now all use the flexi grid developed in this fishery but the Russian vessels do not currently as they say fish catch is reduced considerably. Joint trials are being conducted (Faroe Islands and Russia: Implications: Wider adoption of selectivity device).

Ecosystem Effects

- Gillnet fisheries are now at a very low level in Iceland and therefore lower there are lower bycatch of seabirds and marine mammals recorded. However, longlines fisheries are taking a large catch of fulmars. This is offset with a massive increase in the fulmar. (Iceland: Implications: Unknown).
- Experiments with a combined plate gear with rolling bobbins have been carried out on Norwegian research and commercial vessels in 2007. The final concept was tested in November 2008 and combines roller bobbins and plate gear. Initial assessment suggests this gear has a lower bottom impact than standard rockhopper groundgears but further testing is required (Norway: Implications: Development of low impact groundgear).
- Observation work by Norway on pelagic trawls with specially designed collection bags research has shown that escape from the aft part of the trawl is substantial at times. Some quantification of the escape of blue whiting and herring has been made and is high (Norway: Implications: Unaccounted mortality in pelagic trawls).
- A preliminary investigation was carried out in Iceland to measure the bottom impact of seine gear. The seabed was filmed before and after as well as biological samples taken but no evidence of substantial impact was found. This work is continuing (Iceland: Implications: Bottom impact of seine net gear).
- In Norway there has been extensive testing by industry of pelagic and semipelagic trawling for saithe in the Barents Sea and North Sea. Three trawlers have been involved in 2008/2009. Until 2008, only demersal trawl was used. It is expected that the number of vessels using this technique will increase in 2009. During semipelagic trawling the doors are off the seabed and the opening (27 by 70 m) of the new trawls are approximately 20 times the size of commercial twin trawls

for gadoids. According to information from the fishermen the fuel/kg saithe caught, are reduced. Another reason for trying this technique is the focus on the impact of trawl doors on the seabed (Norway: Implications: Unknown).

- In May 2008 a first field experiment was conducted by Norway to study the mortality of herring after crowding and slipping. The experiments were carried out onboard commercial purse seine vessels in the open sea. It was shown that the mortality was dependent on the degree of crowding. Further experiments have to be done to provide reliable mortality estimates (Norway: Implications: Unaccounted mortality in purse seines).

Development of New Fisheries

- Up to 17 Icelandic pelagic trawlers that were targeting capelin before this fishery was closed have developed an experimental fishery for Pearlsides or Mullers bristlemouth (*Maurolicus muelleri*). Catches have initially been poor (> 700 tonnes in a trip) as the fish is only 4 cm. The fishing gear need to be developed further if this fishery is to continue but the motivation is high as the capelin is closed (Iceland: Implications: Development of new fishery).
- There has been increased interest in Norway in the exploitation of marine zooplankton such as copepods and krill. Several novel methods have been tested using air bubbles to lift Calanus to the sea surface to be skimmed by oil spill recovery type equipment and also by concentrating Calanus closer to the surface to be collected by a small mesh trawl with reduced opening area (Norway: Implications: Targeting of copepods and krill).
- As a reaction to increasing fuel prices and low prices for cod and haddock several large Faroese deep-sea trawlers have applied to the Faroese Ministry to be allowed to pair trawl, although to date none have adopted this fishing method as yet (Faroe Islands: Implications: Moving to new gear type).

WGFTFB report to WGECO, WGMME,WGSE, SGBYC, WGDEEP & WGNEW

Ecosystem Effects

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sessment of the scale of slipping in these fisheries or their likely impact (All countries: Implications: Unaccounted mortality).

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- In Norway there has been extensive testing by industry of pelagic and semipelagic trawling for saithe in the Barents Sea and North Sea. Three trawlers have been involved in 2008/2009. Until 2008, only demersal trawl was used. It is expected that the number of vessels using this technique will increase in 2009. During semipelagic trawling the doors are off the seabed and the opening (27 by 70 m) of the new trawls are approximately 20 times the size of commercial twin trawls for gadoids. According to information from the fishermen the fuel/kg saithe caught, are reduced. Another reason for trying this technique is the focus on the impact of trawl doors on the seabed (Norway: Implications: Unknown).
- In May 2008 a first field experiment was conducted by Norway to study the mortality of herring after crowding and slipping. The experiments were carried out onboard commercial purse seine vessels in the open sea. It was shown that the mortality was dependent on the degree of crowding. Further experiments have to be done to provide reliable mortality estimates (Norway: Implications: Unaccounted mortality in purse seines).
- In the last couple of years there is a growing number of sea turtles accidentally being caught by bottom and pelagic trawlers in the Central Northern Adriatic Sea. It is estimated that in this area more than 4000 turtles per year are caught (Italy: Implications: High catch of protected species).
- In the Tyrrhenian coast of Sicily and Calabria drift nets called “Ferrettara” are still widely used to catch small pelagic species. However for

the technical characteristics these nets are very similar to the illegal drift nets called "Spadara nets" targeting swordfish. The use of the "Ferrettara" is reported to lead to the catch of turtles, cetaceans or sharks but no assessment of the impact of these fisheries has been undertaken. These fisheries are continuing under derogation from the Italian government but no mitigation measures have been put forward (Italy: Implications: Unrecorded bycatch of protected species).

- There is evidence in Portugal of gillnets being fished with long soak times far beyond the national maximum time legally allowed (Portugal: Implications: Source of unaccounted mortality and increased discarding).
- There is anecdotal evidence in both Scotland and Belgium that the ban of high grading introduced into the North Sea under the TAC and quota regulations for 2009 is not working. There are reports fishermen are ignoring these regulations and discarding large quantities of small grade cod due to the quota being very limiting (Scotland and Belgium: Implications: High grading ban).
- There has not been a major shift in mesh size categories (anecdotic information) although some of the Belgian beam trawler fleet have been fishing with trawl nets of 150 mm mesh size instead of 120 mm in the belly of the net during the summer of 2007 and 2008. These changes are especially prevalent on fishing grounds with a lot of weed, hydrozoans and bryozoans, namely ICES subarea IVb and VIIg (Belgium: Implications: Reduced benthic impact).
- Five beam trawlers will be converted to fishing with pulse trawls. The first one has currently started testing the system (Netherlands: Implications: Unknown).
- The beam trawl fleet in both Netherlands and Belgium are feeling the increased pressure of the market not wanting to buy fish caught with beam trawls due to the bad reputation. This incentive is stimulating research on selective nets and ways of diminishing impact. Initiatives have been taken to promote fish products from ecosystem friendly methods, e.g. outriggers. In the UK the Seafish Responsible Fishing Scheme is being used in a similar way but up to 300 UK vessels to promote their catch. These initiatives are likely to continue over the next few years (All Countries: Implications: Better public perception).
- The Dutch beam trawl fleet are voluntarily using longitudinal release holes and benthic release panels made of square mesh in the lower panel of the trawl, which open when nets fill with benthos. Research is being carried out with the industry to optimise a Benthic Release Panel for the Dutch beam trawling segment. This work is continuing in 2009 (Netherlands: Implications: Reduced impact on benthos).
- A new long range acoustic deterrent device has been developed by Germany and Denmark. The device has a detection distance of 400m and is now being used by the Danish and German authorities to monitor pinger usage in the Baltic. Since the adoption of this device several Russian gillnet vessels have been warned over failure to use pingers, which are compulsory in the Baltic to protect harbour porpoises (Germany: Implications: Monitoring of acoustic deterrent devices).

- Tests have been carried out in German with plate groundgear, similar to the groundgear developed in Norway. Initial tests were not successfully, although the gear has subsequently been modified to include roller bobbins in between the plates. Is was found to work well in terms of fuel efficiency and reportedly with reduced bottom impact, although no quantification of this reduction in impact was carried out (Germany: Implications: Testing of low impact bottom trawls).

Development of New Fisheries

- Up to 17 Icelandic pelagic trawlers that were targeting capelin before this fishery was closed have developed an experimental fishery for Pearlsides or Mullers bristlemouth (*Maurolicus muelleri*). Catches have initially been poor (> 700 tonnes in a trip) as the fish is only 4 cm. The fishing gear need to be developed further if this fishery is to continue but the motivation is high as the capelin is closed (Iceland: Implications: Development of new fishery)
- Up to 8 Irish vessels have continued to exploit boarfish and landings in 2008 were estimated at around 10 000 tonnes at a value of over €2 million. All of the catch is being processed as fish meal as it is a very high oil content. No assessment of the potential impact of this fishery has been carried out but it has diverted effort from the blue whiting fishery for which Ireland had a much reduced quota in 2008/2009 (Ireland: Implications: Continued development of a new fishery).
- There has been increased interest in Norway in the exploitation of marine zooplankton such as copepods and krill. Several novel methodas have been tested using air bubbles to lift Calanus to the sea surface to be skimmed by oil spill recovery type equipment and also by concentrating Calanus closer to the surface to be collected by a small mesh trawl with reduced opening area (Norway: Implications: Targeting of copepods and krill).
- A new trammel net fishery for the shrimp species *Metapenaeus affinis* has been developed in the Bay of Izmir, on the Aegean coast of Turkey. This species is an alien species to the areas but has a higher commercial value and longer fishing season so has now become more important that the native Mediterranean prawn *Melicertus kerathurus* (Turkey: Implications: Development of new shrimp fishery).
- There have been increased catches of John Dory in Area VIIb-k in recent years and this species is now widespread and abundant all over the grounds. Catches of up to 300 kg per haul have been recorded with vessels consistently landing 100kg–150kg of John Dory consistently per trip (Ireland: Implications: Increased John Dory catches).
- As indicated 3 French vessels and up to 8 Dutch have been converted to seining. These vessels are targeting mixed demersal species in VIIb-k (most effort in VIIg) and also species such as red mullet, gurnard and squid in VIId and IVb. These vessels are much more powerful than seine net vessels in Ireland and Scotland as they are converted vessels (beam trawlers, whitefish trawlers and one tuna purse seiner) (France and Netherlands: Implications: Trageted fishery on non-quota species).

WGFTFB 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, Turkey and a limited amount of information from France.

Fleet dynamics

- Several Italian pair pelagic trawlers are considering moving to single-boat pelagic trawling as it is felt this is much more efficient for targeting certain species. This is still at the development phase but many fishermen are keen to move to this method (Italy: Implications: Unknown).
- Due to restrictions on fishing for Bluefin tuna with drift nets a number of French vessels have shifted to longlining for Bluefin Tuna or using trammel nets for Dover Sole. This has been primarily in the Western Mediterranean (Areas 37.1.1 and 37.1.2) (France: Implications: Shift of effort away from driftnets)

Technology Creep

- In the last few years some Italian bottom trawlers of the central-northern Adriatic, switched their activity from single- to twin-rig trawling (named by the Italian fishermen: *"Americana trawl"*). This change has been introduced to increase the bosom height as well as the horizontal opening of the trawl made. There is a big concern, though from fishermen 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 (Italy: Implications: Increased fishing effort).
- There has been some initial testing in Italian bottom longline fisheries with Norwegian style hook designs (Mustad: EZ baiter, Wide Gap, Wide Gap (eyed hooks). This work showed these hooks to be far superior to traditional J hooks used by the Italian fleet and widespread adoption of new hook patterns is anticipated (Italy: Implications: Increased efficiency).
- There is evidence in the Gulf of Lions (Area 37.1.2), of a reduction in the trawl size being used by French vessels or shifting from single rig trawling to small twin trawling mainly to reduce fuel costs (France: Implications: Reduction in trawl gear).

Technical Conservation Measures

- As reported in ToR d there has been problems with the introduction of new technical measures in the Mediterranean and in particular the use of 40 mm square mesh codends. There have been difficulties in the interpretation of the regulations in Italy, leading to a delay in introducing the 40 mm square mesh codend. There have been a number of tests with the 40 mm square mesh codend subsequently and these have shown it to give higher selectivity for some species but it does not avoid some of the existing contradictions in between codend mesh size and MLS. Work is continuing to look at the impact of the 40mm square mesh codend in Italy, Turkey and several other countries. Trials in Turkey indicated that the new 40 mm square mesh codend gives higher selectivity for most Mediterranean species although adoption of the square mesh codend has been very low or non-existent in Turkey (All countries: Implications: Unknown).

Ecosystem Effects

- In the last couple of years there is a growing number of sea turtles accidentally being caught by bottom and pelagic trawlers in the Central Northern Adriatic Sea. It is estimated that in this area more than 4000 turtles per year are caught (Italy: Implications: High catch of protected species).
- In the Tyrrhenian coast of Sicily and Calabria drift nets called "Ferrettara" are still widely used to catch small pelagic species. However for the technical characteristics these nets are very similar to the illegal drift nets called "Spadara nets" targeting swordfish. The use of the "Ferrettara" is reported to lead to the catch of turtles, cetaceans or sharks but no assessment of the impact of these fisheries has been undertaken. These fisheries are continuing under derogation from the Italian government but no mitigation measures have been put forward (Italy: Implications: Unrecorded bycatch of protected species).

Development of New Fisheries

- A new trammel net fishery for the shrimp species *Metapenaeus affinis* has been developed in the Bay of Izmir, on the Aegean coast of Turkey. This species is an alien species to the areas but has a higher commercial value and longer fishing season so has now become more important that the native Mediterranean prawn *Melicertus kerathurus* (Turkey: Implications: Development of new shrimp fishery).

Annex 8: Response to NAFO on reducing the bycatch of cod

Executive Summary

At the ICES-FAO WGFTFB meeting of 19–22 May 2009, an *ad hoc* group of WGFTFB members met to address a request from NAFO, "to advise NAFO SC on appropriate gear modification, or other technical measures relating to fishing gears, that would ensure that the bycatch of cod is kept at the lowest possible level".

This *ad hoc* group reviewed the behavioral characteristics of cod and of other species which often mix with cod and considered strategies to separate cod (*Gadus morhua)* from flatfish species, including yellowtail flounder (*Limanda ferruginea)* as well as from other species.

Behavioral reviews revealed that differences between cod and other species do exist, either in terms of natural separation or in its reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations.

The group identified several trawl modifications aimed at specifically separating cod from both yellowtail flounder and other flatfish species and also examined modifications to sort cod from other commercial species. Operational methods of non-trawl gears which were aimed at separating or reducing cod in other groundfish fisheries in the North Atlantic were also briefly considered.

The *ad hoc* group compiled a summary of the studies under the following headings

- Fish behaviour and the principles of species separation
- Gear modifications developed to separate cod from flatfish
- Gear modifications developed to separate cod from other species
- Identification of separation in non-trawl gears

WGFTFB cautions that in the absence of specific details such as gear descriptions, vessel types and management objectives, no single gear modification can be recommended at this time to NAFO. WGFTFB, however, has identified some gear modifications that demonstrate that the separation of cod from other species, including flatfish, is possible. This can be achieved by modifying the front section of the trawl, installing a sorting device such as a rigid grid or separator panel, by using large mesh escape panels positioned above the codend or by modifying the codend itself. These do need, though, to be tailored to the specific requirements of a given fishery and limitations with all of these gears have also been identified and documented. Other modifications such as the "Eliminator" and Raised footrope trawls have been proven to eliminate cod catches almost entirely but are only really suitable for targeted haddock fisheries.

Studies examining separation techniques for non-trawl gears were also identified and briefly reviewed. These include modifications to Scottish seines, gillnets, longlines and pots. Testing of gear modifications to Scottish seine nets is an extension of similar modifications made to trawls. The limited data available is inconclusive but it seems technically feasible to target flatfish with this gear with reduced cod catches.

There has been extensive work with gillnets in recent years and through simple modifications significant reduction in cod catches can be achieved when targeting flatfish species. Gillnets are accepted as selective gears and further research on a commercial basis to establish whether these modifications can yield catches at economically viable levels of other species should be encouraged.

Using bait to sort catches in longline fisheries seems technically feasible but has only really been used to reduce cod catches in targeted haddock longline fisheries. More research is needed to establish whether this can be extended to other fisheries where cod is considered an unwanted bycatch due to stock pressures.

Experiments with fish pots are widespread in many areas and fisheries. Most of this work has concentrated on developing selective fisheries for cod. There are several reports of attempts to develop flatfish pot fisheries but catch rates observed have been at low levels and pot fisheries for fish remain in a developmental phase.

Request

In September 2007, the NAFO Fisheries Commission requested the following scientific advice from the NAFO Science Committee: "Noting the FC Rebuilding Plan for 3NO cod adopted in September 2007, Fisheries Commission requests Scientific Council to advise, before September 2010, on a range of possible management measures to ensure bycatch of cod is kept at the lowest possible level."

NAFO SC examined the effects of temporal and spatial changes in fishing effort for the yellowtail flounder (*Limanda ferruginea)* trawl fishery and in June 2008 responded to NAFO FC. However, NAFO SC noted that modifications to fishing gears may further reduce the bycatch of cod but did not have the expertise to provide a detailed analysis.

Following an informal request by NAFO to the chair of the ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB), a summary table of current research findings was produced and forwarded to NAFO. On foot of this information, NAFO made a formal request to ICES as below:

Under the terms of the MoU between NAFO and ICES, NAFO SC requested that WGFTFB, "to advise NAFO SC on appropriate gear modification, or other technical measures relating to fishing gears, that would ensure that the bycatch of cod is kept at the lowest possible level".

At the WGFTFB meeting of 19–22 May an *ad hoc* group of WGFTFB members met to address this request from NAFO. The chair of WGFTFB has taken this information and produced this document as an attempt at addressing NAFO's specific request but it should be noted that it may not necessarily reflect fully the views of all the contributors.

Background to Request

The spatial distribution of Div. 3NO cod in Canadian spring and autumn research vessel surveys was examined to determine if areas of concentration were consistent enough to allow for spatial avoidance of cod bycatch. The distribution of cod in 15 surveys from 2000 to 2007 was examined, as were previous publications of cod distribution in Div. 3NO. Cod are generally widespread throughout Div. 3NO, although in low abundance. There were no consistent areas of high concentration. This lack of a consistent spatial distribution indicates that there is little opportunity to avoid bycatch of Div. 3NO cod by restricting fishing to certain areas, at least in the period of the year covered by the spring and autumn surveys.

Based on STACFIS estimates, since 2000, Canadian fisheries have accounted for on average 32% of the total Div. 3NO cod bycatch, with the percentage ranging from 16-64%. On average 92% of the bycatch taken by Canada is taken by Canada NL. Examination of landings data from Canada NL shows a clear temporal trend with most bycatch of Div. 3NO cod being taken in the second half of the year, particularly in months 9 and 10. The most important fishery is for yellowtail flounder which has taken, from 61–87% of the bycatch taken by Canada NL over the 2000–2007 period, except in 2006 when that fishery only operated for three months at a much reduced level.

Percentage bycatch of Div. 3NO cod in the Canada NL yellowtail flounder fishery was highest in months 8–10 in almost every year (Figure 1). Bycatch percentage was also high in July, a month when yellowtail fishing is generally limited because of a closure for spawning. Catch of yellowtail flounder on the other hand is generally distributed throughout the year with peaks in months 4–5 and 8–10 (Figure 1). From 2000–2005 (years when the Canada NL yellowtail flounder fishery operated on a normal basis), catch in the first six months of the year made up on average 46% of the total yearly catch.

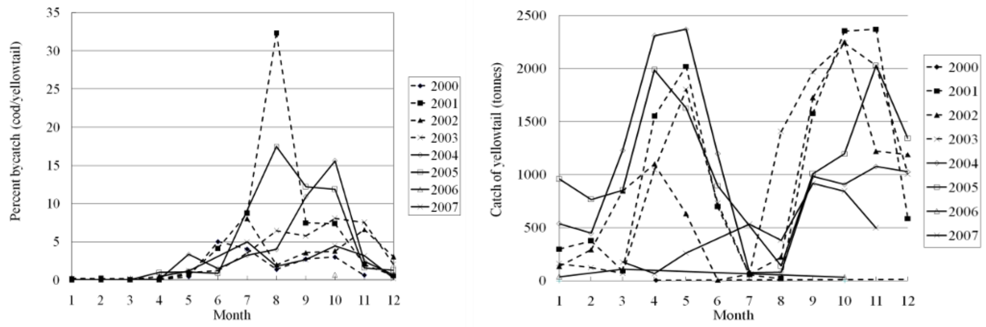


Figure 1. Percent bycatch of Div. 3NO cod in the Canada NL yellowtail flounder fishery by month and year (left) and catch of yellowtail flounder by month and year (right) in that same fishery

A series of scenarios were developed to examine the impact on bycatch of redistributing the yellowtail catch from months with the highest cod bycatch in fishery for yellowtail flounder conducted by Canada NL (Table 1). In each scenario the total catch of yellowtail flounder was the same (12 500 t), the average catch during 2003–2005 and the expected yellowtail flounder catch by Canada NL with a quota of 15 000 t. Assuming average monthly bycatch rates, a fishery spread over the year in the pattern usually observed would take 400 t of cod bycatch. If the same amount of yellowtail flounder was caught but fishing did not occur in months 6–11, bycatch could be reduced by 85% in this fishery. If months 7–11 were avoided bycatch could be potentially be reduced by 76% and if directed fishing for yellowtail flounder avoided months 7–10, bycatch could potentially be reduced by 66%. It should be kept in mind that the Canada NL fishery operates only on a limited basis in July (month 7) so that this scenario (no fishing month 7–10) would result in a closure of three months compared to the current fishing practice. If the catch of yellowtail flounder in months 7–11 was decreased by 50% and that amount of catch equally distributed across the other months, the bycatch of cod in the Canada NL yellowtail flounder fishery could be expected to decline by 38%. There appears to be substantial potential to decrease bycatch of Div. 3NO cod in the Canada NL fishery for yellowtail flounder by avoiding fishing in months when cod bycatch is highest (months 6–11).

Scientific Council noted that these analyses apply only to the directed yellowtail flounder fishery conducted by Canada NL. Fisheries conducted by other contracting parties in Div. 3NO could also be examined for the potential for temporal avoidance of cod bycatch. Scientific Council, however, also noted that there may be other measures, such as gear modifications, that could be effective at avoiding cod bycatch. Such gear modifications are seen as a means to complement spatial and temporal measures and past experience in other fisheries e.g. the use of grids in shrimp fisheries have shown them to be much more acceptable to fishermen. Following an initial request from NAFO to ICES WGFTFB a summary table of possible gear measures was provided by WGFTFB. The identification of potential "cod reduction" gear modifications was basis for this formal request to ICES.

Table 1 Catch of yellowtail flounder and cod (tonnes) based on the mean percentage bycatch of cod each month in the yellowtail fishery, taking a yellowtail catch of 12,500 t over 12months with normal catch pattern, 6, 7 or 8 months or 12 months with catch reduced in months 7–11 by 50%.

		Fish in all months		Fish in 6 months		Fish in 7 months		Fish in 8 months		Reduce 7-11 by 50%	
Month	percent bycatch	catch ytail	catch cod	catch ytail	catch cod	catch ytail	catch cod	catch ytail	catch cod	catch ytail	catch cod
1	0.08	425	0	2083	2	1786	1	1563	1	786	1
2	0.08	418	0	2083	2	1786	1	1563	1	779	1
3	0.03	669	0	2083	1	1786	1	1563	1	1030	0
4	0.30	1674	5	2083	6	1786	5	1563	5	2035	6
5	1.26	1743	22	2083	26	1786	23	1563	20	2104	27
6	2.54	711	18	0	0	1786	45	1563	40	1072	27
7	5.42	67	4	0	0	0	0	0	0	33	2
8	9.34	382	36	0	0	0	0	0	0	191	18
9	6.46	1562	101	0	0	0	0	0	0	781	50
10	7.73	1935	150	0	0	0	0	0	0	967	75
11	3.42	1827	63	0	0	0	0	1563	53	914	31
12	1.27	1100	14	2083	26	1786	23	1563	20	1461	19
	sum	12513	412	12500	63	12500	99	12500	140	12153	256
bycatch reduction (%)					85		76		66		38

Fish behaviour and the principles of species separation

When addressing bycatch and discard issues it is important to understand the temporal and or spatial distribution of target and non-target species. For some species, moving fishing operations from one area to another or from one timeframe to another may be sufficient to reduce or eliminate bycatch altogether. However, in data poor fisheries where such detailed distribution information may not be available, or where species are known to co-habitat fishing grounds, other strategies may be necessary.

Historically, separation of one species from another, in trawl fisheries, has been most successful where clear, definable and repeatable differences in behaviour, swimming performance and or shape, exist between target and non-target species. Where no such differences exist, separation has invariably proved problematic. Furthermore, even where clear behavioural differences exist, separation may prove difficult or impossible when fish are encountered in very large quantities and their behaviour is modified.

The process by which fish enter and are retained by a trawl net involves a complex sequence of behavioural reactions to different components of the trawl gear. Much of what is known about behaviour has been gained from a limited amount of video and direct observation by divers under well-lit conditions. It is not always quantitative and for many species, the full range of behaviour under all environmental conditions is not well understood.

The fish capture process begins well ahead of the vessel where fish initially detect and respond to low frequency noise produced by the vessel, warps, doors, and trawl net. Knowledge of species- and size-specific response to these stimuli is limited, and there is limited opportunity (currently) to apply this knowledge to modify trawl selectivity. Between the trawl doors and the net, the behaviour of roundfish and flatfish may be substantially different. Roundfish such as cod often respond visually to the trawl doors and sand clouds at a distance of meters or tens of meters, swimming in a direction and speed that maintains visual contact with the "threat", either unwittingly into the path of the net, or in a direction that avoids capture (Wardle, 1983). In many instances the visual stimulus of the trawl net is not apparent at this stage but fish are herded towards it by the sand clouds, sweeps and bridles.

Consistent with their anti-predator strategy, (detection-avoidance), flatfish typically remain close to the seafloor throughout the capture process. Their reactions also tend to be at a much shorter distance compared to roundfish, at least under conditions where visible reactions might take place, typically less than 1m (Main and Sangster, 1981; Walsh and Hickey, 1993; Ryer and Barnett, 2006). Flatfish swimming behaviour typically consists of short high-speed bursts followed by slow swimming or resting. Their swimming trajectory is approximately perpendicular (90^{o}) to the sweeps and lower bridles, and this results in the fish 'slipping' along these wires toward the path of the net.

Different species and sizes of fish arrive at the mouth of the net in varying physiological conditions depending on their previous avoidance behaviour. For many species, the most common response is to orient in the direction of tow and keep station with the advancing trawl. This behaviour occurs at high light intensities and appears to be an optomotor reflex in response to the visual cues (contrast) produced by the surrounding footgear and netting panels. For some species this reflex produces a strong motivation to maintain position (or station) within the mouth of a moving trawl, while for other species the response is less apparent or non existent, producing a more erratic behaviour in the trawl mouth.

Some of the earliest observations of cod behaviour were made in shallow, well-lit Scottish waters by divers observing fish from a vehicle towed alongside the trawl (Main and Sangster, 1981). Cod were not seen in large numbers during these experiments but individuals were first observed swimming in the direction of the tow, close to the seabed well ahead of the ground gear. As they tired, the swimming gait changed from steady to unsteady "kick and glide" action and then to a very pronounced, fast zig-zag track between left and right quarters in front of the approaching groundgear, before eventually turning horizontally, close to the sea bed and either swimming into the net close to the belly netting panel or escaping under the bobbin spacers. This behaviour is markedly different to that of other species such as haddock and whiting, which are observed to rise up as they turn and enter the net higher off the bottom or even escape over the headline and has been utilized to separate cod from haddock in North Sea waters using horizontal separator panels placed up to 19m behind the ground gear. The results indicated that 86–90% of cod stayed below a separator panel of 0.8–1.5 m high during the day, but separation was significantly reduced (as little as 40% being caught in the lower codend) during the night (Ferro *et al*., 2007). Flatfish typically have a lower swimming endurance than roundfish (except for species such as halibut) and again, very rarely swim at any great height above the seafloor.

Cod have also been observed escaping under the groundgear of trawls. An experiment conducted in the Barents Sea (Ingolfsson and Jørgensen, 2006) quantified the rate of escapement under the groundgear of a commercial demersal trawl fitted with 22" hoppers by attaching a series of three retention bags to the back of the groundgear. Due to problems with bottom topography, only eight valid hauls were obtained with catch rates ranging from several hundred kilos to several tonnes. Hauls were conducted in deep water 250–300 m and during darkness/twilight, no full daylight hauls were conducted due to the time of year and the high latitude. Data were obtained for Atlantic cod, haddock (*Melanogrammus aeglefinus)* and saithe (*Pollachius virens*). Retention in the trawl was found to be length dependant for cod, with the smaller fish having a higher probability of escapement under the groundgear. On average, 48.6% of cod less than 50 cm escapes under the gear and 25.9% of cod above 50 cm escapes under the gear. Overall, an average of 36.6% of the cod escapes under the gear.

Having entered the net and reached the relatively confined funnel section of netting immediately ahead of the codend (sometimes called the extension or intermediate section), some species, including haddock and cod, will turn and swim in the towing direction. As exhaustion sets in, each individual will slow and eventually enter the extension, where increased crowding may disrupt their orderly behaviour and elicit randomly orientated burst-swimming behaviour. This behaviour is likely to cause collision with netting or other fish, or even the escape of small individuals through the side and upper meshes of the trawl net.

During their experiments with "Ribas" and "topless" trawls, Pol *et al.* (2003) and Chosid *et al. (*2008) collected qualitative video observations of fish behaviour. In front of the trawl, cod swam near the footrope, but further back in the net they observed cod in the upper half of the trawl above the sand clouds and two cod were seen to escape through the meshes in the upper part of the trawl. These observations supported the catch data where a reduction of cod catch exceeding 76% for both nets was recorded. The headline heights for these nets were relatively low (~2m) so the rising behaviour of cod was not very high, but enough to allow escape either through large top panel meshes or through the gap where the top panel had been cut back. The authors also noted that flounder exhibited consistent behaviour swimming in short bursts in front of the footrope before appearing to tire and tumble back in the net, typically remaining close to the belly of the trawl.

The vertical location of fish during passage through the extension of a trawl net is often highly variable and sometimes species-specific. Recent experiments used a rigid frame and vertically stacked codends to assess the vertical separation of fish in this part of the net (Krag *et al.*, 2009). Video observations of cod ahead of the frame indicated no reaction to its presence and commented that cod behaviour was less consistent than that observed for haddock and whiting (*Merlangius merlangus*) with movement both horizontally and vertically. The authors noted that "Cod appeared calm and showed no signs of panic or made no attempt to escape". This lack of escape activity has been noted from video of cod behaviour in other studies.

The behaviour of flatfish in the extension can also be highly variable, and may range from dynamic to passive, or a combination of both behaviours. Most fish that enter a codend are considered to be exhausted and have limited capability for sustained swimming. The passage of fish from the net mouth to the codend may therefore take several seconds or longer, depending on fish condition (stamina and available reserves of energy), swimming direction, towing speed, and length of trawl net. Upon reaching the codend, individuals may become part of the accumulated catch, or turn and swim ahead of the catch for a period of time (Watson 1988; Wardle 1992; O'Neill *et al.* 2003). Small fish may be passively filtered through the netting, while those still capable of active swimming may be able to detect, orientate and swim through open meshes of the codend and escape.

Gear modifications developed to sort cod from flatfish

There have been a number of attempts at developing trawls specifically to reduce cod catch while maintaining catches of flatfish species, including yellowtail flounder. In itself the development of such gears is problematical given, as described above, the behaviour of cod and flatfish is very similar. However, there are examples where this objective has been attempted, which the group considered worth of noting. In addition several gear modifications that simply improve size selectivity of cod while not impacting on flatfish catches are also noted. The gears considered are as follows:

- Faroese Cutaway Trawl
- Ribas Trawl
- US Topless Trawl
- Very Low-opening Trawl
- Danish Selective Flatfish and Whitefish Trawls
- Horizontal Separator panels (American plaice vs. cod)
- Rigid Grids
- Square & Composite Codends
- Large Square Mesh Panels & Bacoma windows
- Modifications to beam trawls

Faorese Cutaway Trawl

Thomsen (1993) reports on trials carried out in the Faroe Islands where a standard 420 mesh (135 mm) whitefish trawl was modified by extending the length of the head line so that it was set approximately 7 m behind the ground gear. The upper wings were also removed as shown in Figure 2 below.

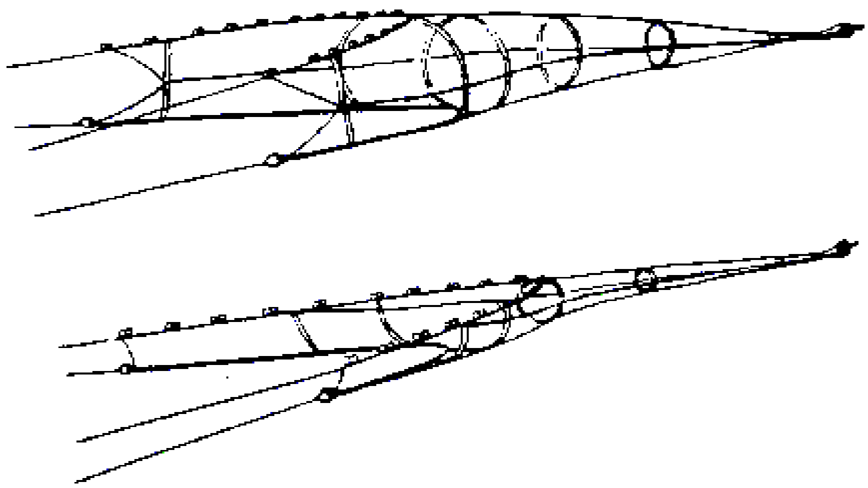


Figure 2. Impression of standard net (top) and trawl with extended headline (bottom).

Observations conducted on the modified trawl showed cod and flatfish entering close to the lower belly. However, further back in the trawl, cod were seen reaching the upper panels from the beginning to the middle section of the upper bellies. As a result of these observations, some of the 135 mm netting was replaced with netting with a mesh size of 540 mm. The panel length was approximately 2 meshes of 540mm mesh deep by 2 meshes wide.

The alternate haul technique was used to determine effectiveness of modified trawl. Catch rates from 24 hauls with the standard net and 21 hauls with the modified net were compared. Despite large variations in catch and species composition between hauls, there was a significant reduction of cod, haddock and saithe, with no significant difference for other species including flatfish. On average the catch rate of cod was reduced by 38% and catches of haddock and saithe by over 90% with no reduction in flatfish catches.

Ribas and US Topless Trawls

Behavioural observations outlined in the previous section were used by Pol *et al.* (2003) and Chosid *et al.* (2008) to test two different designs of trawls to reduce the capture of Atlantic cod in the New England US mixed fishery. The objective was to assess if it was possible to retain the catches of flatfish species, mainly yellowtail and winter flounder (*Pleuronectes americanus*) and exclude cod due to restrictive quotas.

Two modifications were tested:

- The "topless" net design, which followed that suggested by Thomsen (1993) and described above.
- A modified trawl (the so-called "Ribas" trawl) with large square mesh panels in the top sheet and a codend of mesh size of 160mm knotted square mesh.

As a departure from the standard net used in the fishery, the "Ribas" net replaced the 152 mm diamond upper belly and extension sections with 203 mm square mesh, and for Pol *et al.* (2003) the design differed from the standard trawl by having equal headline and fishing line lengths and a reduction in fishing circle from 280 to 200 meshes, although the length of the fishing line is the same. There was also a different depth and taper in the belly section.

The Topless modification (Pol *et al,*. 2003) was based on the design concept used by Thomsen (1993), where the square and upper wings were removed and the headline length increased, so as to set the headline behind the fishing line. As with the Ribas net, other important departures from the control design included the difference in fishing circle and belly depth and cutting rate.

Cod catch rates in both nets were found to be reduced and these reductions were found to be statistically significant. Pol *et al.*(2003) concluded that this reduction in cod catches may have been a result of the headline heights in these nets being much lower, ~2 m, than other whitefish trawls commonly used in European fisheries. Therefore cod do not have to rise much to reach the top panel and can therefore escape more easily. The results are given in Table 2.

Table 2. Reductions in Cod Catches achieved with the Ribas and Topless Trawls.

FISH CATEGORY	% REDUCTION IN CATCH RATE	
	Ribas net	**Topless net**
Cod	72%	87%
Yellowtail > MLS	38%	32%
Yellowtail < MLS	75%	81%
Winter flounder > MLS	56%	45%
Winter flounder < MLS	82%	61%

Results for yellowtail > minimum landing size showed catch rates were significantly lower for the Ribas net. Reductions observed with the Topless net, however, were not significantly different from the standard net. Both experimental nets caught significantly lower catches of smaller yellowtail. There was no evidence from the video observations as to how this decrease in catch rate of flatfish occurred but yellowtail were rarely seen to escape through the top panel, suggesting they did not react to the cutaway section. For winter flounder the topless net caught large fish at similar rates to the standard, but the Ribas net caught fewer. Both nets caught significantly lower rates of smaller winter flounder.

Pol *et al.* (2003) noted that certain technical differences between the standard and experimental nets could have been the cause of some of the variation in catch rates in that there were differences in the size of the fishing circles, although the footropes of all three designs were the same and therefore swept the same area. The way the experimental nets were rigged possibly altered bottom contact in comparison to the standard net, which may have altered behaviour. Specifically referring to the loss of marketable flatfish, the authors suggested a number of reasons. Some fish were observed spilling out of the topless net during haul back. Pol suggested that it maybe possible to use "net lockers" to close the codend once towing stops to avoid this although this has not been tested. Also flume tank testing of the topless trawl indicated that the wings tended to lean outwards and this was observed from underwater observations subsequently. This over spreading of the wings would reduce the herding efficiency for flatfish and thus reduce catches.

These designs were further testing on a larger scale, in deeper water, and around the clock (Chosid *et al.*, 2008) and resulted in different conclusions. The control and experimental nets were designed and constructed similarly except for the described modifications. The experimental nets were compared using a commercial fishing vessel over three trips (November 2003, March 2004 and December 2006) using twin trawling (two nets towed at the same time) and alternate trawling (control/experimental net singly in a rotation) against a standard control flatfish net.

Results showed significant reductions in catch in the Topless net for Atlantic cod, legal and sub-legal sized yellowtail flounder, American plaice (*Hippoglossoides platessoides)*, grey sole (*Glyptocephalus cynoglossus)*, haddock (*Melanogrammus aeglefinus)*, monkfish (*Lophius americanus)*, winter flounder (*Pseudopleuronectes americanus)*, and American lobster (*Homarus americanus)*. The Topless net results showed that Atlantic cod, American plaice, and haddock were significantly reduced during the day and night; grey sole was only significantly reduced during the day and legal and sub-legal yellowtail flounder and winter flounder were only significantly reduced during the night. The Ribas net significantly reduced legal and sublegal yellowtail flounder, American plaice, grey sole, and haddock catches and no diurnal effects were seen. Analyses did not detect any substantial length frequency difference between nets; some changes in the size structure of species, particularly haddock and yellowtail flounder, were observed.

Lower catches of Atlantic cod in the Topless net and not with the Ribas net suggest that the presence of any netting in the upper square section inhibited escapement which was independent of diurnal condition. Haddock were significantly reduced in both experimental designs at either diurnal period indicating that haddock could perceive and escape through large openings in any light condition. Monkfish and lobster showed significant reductions in only the Topless net during the day and night which may indicate a partial passive escape mechanism due to low resistance in the Topless net's wings and additional escape opportunities than available in the Ribas net. Flatfish results were varied with respect to nets and diurnal periods and may be due to species, size, ontogenetic, and gender specific behaviours.

The Topless net met the goal of significantly reducing Atlantic cod catches during the day and night. However, legal-sized yellowtail flounder were only adequately retained in this net during the day which emphasizes the importance of diurnal cycles and/or light levels on the reaction of fish to trawl gear. Failures of the Ribas net to reduce cod catch conflict with the results of the inshore daytime research and may be due to different net sizes, larger vessels, greater geographic and depth ranges, and diurnal conditions.

Chosid *et al.* (2008) conclude that "a modified Ribas and a Topless design are mandated for use during a 24-hour flatfish fishery on USA Georges Bank. Observer and other data from this fishery should be examined to see if actual fishery results are consistent with our testing; if they are managers should re-examine the use of the Ribas and the Topless net to reduce Atlantic cod in a flatfish fishery. Additionally, the economic potential and practicality of the Topless net should be examined for applied daytime flatfish fisheries where roundfish reductions are desired".

Very Low-Opening Trawl

Pol *et al.* (2003) also briefly tested a "lowrider" or very low-opening net in use by a commercial fisherman that reportedly had very low levels of cod catches while maintaining catches of other commercial species including flatfish. The lowrider net was constructed of 15.1 cm diamond mesh PE with 16.5 cm knotless mesh in the codend. A non-scaled model was examined in flume-tank testing. The headrope and footrope lengths were 12.2 m and 18.3 m. The ground gear consisted of 27.4 m of cable with 6.4 cm rubber discs ("cookies"). The headrope height of this trawl was found to be below 1 ft (30 cm) but paired tow comparisons to a standard net design indicated no change in the overall catch rates of cod (t-stat = 0.011, df = 5, p = 0.99). No further analysis was conducted on these results, and no further testing was conducted.

Danish Selective Flatfish Trawl

The objective of this work reported by Madsen *et al.*, (2006) was to develop a trawl suitable for directed fisheries for flatfish, mainly plaice (*Pleuronectes platessa*) and flounder (*Platichthys flesus*) that would reduce cod bycatch. A selective flatfish trawl was developed and tested in a flume tank and then initially in a sea trial conducted in the Danish plaice fishery in the Skagerrak. A further two sea trials were carried out in the Baltic Sea flounder fishery. The catches from the selective flatfish trawl were compared to catches made with a conventional flatfish trawl. The selective flatfish trawl caught more plaice and reduced the cod bycatch, particularly those smaller than the minimum landing size in the Skagerrak sea trials, compared to the conventional flatfish trawl. The selective flatfish trawl caught more flounder and reduced cod bycatch during two sea trials in the Baltic Sea.

A two-panel trawl design was used. To allow gadoid fish out of the trawl, large meshes (400 mm full mesh) were inserted into the trawl in a triangle extending down through the square and the first belly section. This meant that the large meshes covered the entire region where the mesh opening is controlled by the hanging of the net on the headline. This design was preferred rather than the design used by Thomsen (1993), where the headline was moved far back behind the ground gear, because it ensured good bottom contact, which is essential when fishing for flatfish. To keep a low vertical opening in the trawl only 42 kg flotation was attached to the headline. The wings and the square sections were cut along the bars to make this region as large as possible. Drop meshes were introduced along the headline to achieve a long headline for the size of trawl, enabling a large wing end spread and increasing the seabed area swept by the trawl. The steep cut along the selvedge in the wings combined with the drop meshes along the foot rope were made to ensure good ground contact. Furthermore a piece of chain was attached to each wing to ensure that the wings kept contact with the bottom. The heights of the wing ends were measured to be between 0.7 and 0.8m at towing speeds from 2.5 to 3.0 knots (flume tank measurements scale 1:7). However, it was important that this change did not influence the height of the trawl immediately after the large meshes. The trawl height at this location was measured to 0.8–1.05 m. For the trials in thee Skagerrak the codends were 3mlong with a lifting strop placed midway. A 3 m long full square mesh section was inserted in front of the codend. For the trials in the Baltic codends with side square mesh windows that reaches up to the end of the codend were attached to the selective flatfish trawl as at the time of the trials these were required under legislation. Figure 3 shows the selective trawl used.

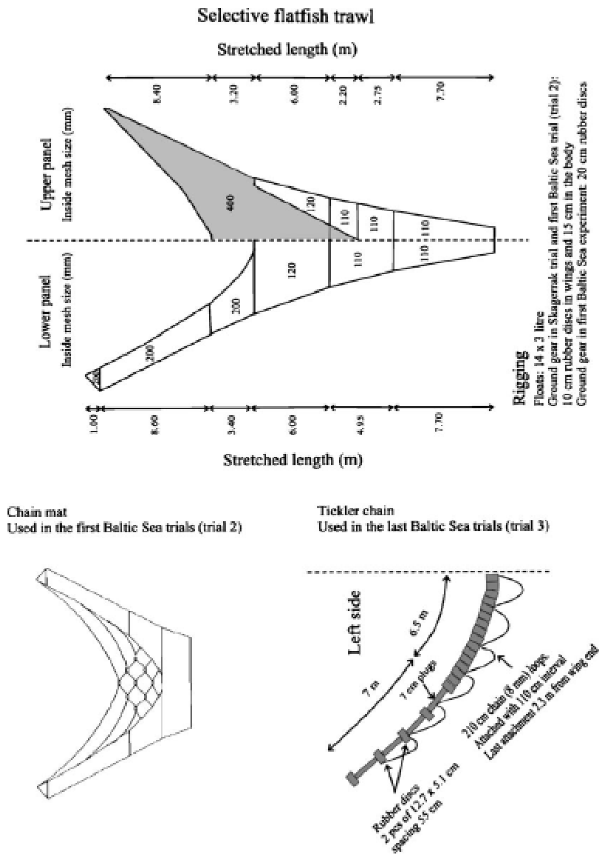


Figure 3. Net diagram of the selective flatfish trawl is shown at the top. Ground gear riggings used in Baltic trials are shown below.

The total reduction of cod by numbers per kg caught of plaice larger than the MLS was 25%. The reduction of cod by numbers smaller than the MLS was 64%. The reduction of catches of cod larger than the MLS was 20% and 7% by numbers and weight, respectively. It was also found that 14% more plaice larger than the MLS were caught in the selective trawl. In comparison to the standard trawl, catches of common dab (*Limanda limanda*) were relatively unchanged while catches of lemon sole (*Microstomus kitt*) decreased. This decrease may have been caused by the low maximum width of lemon sole, compared to plaice. Consequently lemon sole will escape through the wings and the square mesh sorting panel. Catches of cod smaller than the MLS were also lower in the selective flatfish trawl compared to the standard trawl. The reduction of catches of cod smaller than the MLS was 64% and the overall reduction 25%.

An interesting aspect of this work was that the cod catch in the selective flatfish trawl included proportionally more big cod > 50cm. Most of these cod could easily have escaped through the large meshes in the top panel but this finding indicated that the bottom seeking behaviour of cod is the overriding factor determining their capture in trawls such as this, although turbidity of the water might also have influenced the visual stimuli. It was concluded that the large meshes of the selective flatfish trawl provided a better flow through the trawl. Larger fish with better swimming performance than smaller fish therefore have decreased possibilities to swim out of the trawl.

This theory is supported by the skipper and the vessel used in this fishery as after these sea trials the skipper installed large meshes in the top panels of his own trawls and increased his catches of large cod.

As expected, the square mesh section used in these sea trials did not have any influence on the catches of plaice larger than the MLS. The panel was probably the main reason for the decrease in cod catches. The 130mm panel seemed to be able to exclude cod up to about 50–55 cm from the catch. Table 3 summarizes the results from the trials carried out in the Skagerrak and Baltic.

Table 3. Differences in cod catches comparing the conventional trawl to the selective flatfish trawl.

	DIFFERENCE/KG PLAICE ≥ MLS (%)	DIFFERENCE/KG FLOUNDER ≥MLS (%)	
	Skagerrak (trial 1)	Baltic Sea (trial 2)	Baltic sea (trial 3)
Cod total	-25	-85	-67
Cod no. < MLS	-64	-88	-56
Cod no. ≥ MLS	-20	-83	-68
Cod kg. ≥ MLS	-7	-82	-68

Danish Selective Whitefish Trawl

Observations of fish behaviour were conducted in the EU-RECOVERY project with cameras and separator frames on both research and commercial vessels on a standard Danish whitefish trawl as reported by van Marlen. (2007). Two cod selective gear designs were subsequently made based on the collected fish behaviour, literature findings and flume-tank tests. A fixed inclined separator panel (FISP) (Figure 4), and a large mesh top panel (LMTP) design using 800 mm meshes were tested (Figure 5) in the flume tank. Commercial trials were then carried out with 22 and 25 valid tows respectively for the two designs.

Figure 4. The FISP viewed from the side.

Figure 5. LMTP (800 mm) installed in the entire last tapered section.

Both designs enabled lower cod catches, but were deemed to require further development as losses in other commercial species including flatfish species such as plaice and lemon sole were also high. A cleaner *Nephrops* fishery seemed possible though as reported by Van Marlen *et al.* (2007) in the final RECOVERY report.

The FISP reduced the catch of cod over all sizes by 72% (number of individuals) but the catch of all other fish species was severely reduced. Catches of plaice and lemon sole were reduced by 23% and 46% by weight respectively. A catch increase was observed *Nephrops* (9%) and a possible explanation for this increase was due to improved bottom contact compared to the control gear due to a significant smaller total catch weight. The catch composition in the control trawl was of a highly mixed nature. In comparison, the catch caught with the FISP could be characterized as a species selective *Nephrops* fishery rather than a mixed species fishery. The cost, in term of catch loss was very high (57% loss in value), which was deemed commercially unacceptable.

The LMTP reduced the catch of cod over all sizes by 43%. Other important species like saithe, witch (*Glyptocephalus cynoglossus*), lemon sole and haddock were, however, also severely reduced. Plaice catches were reduced 17% by weight and lemon sole by 51% by weight. The catch of *Nephrops* was relatively unaffected. The overall catch value was reduced by 36% compared to the standard gear. The LMTP design was half as efficient in selecting cod out as the FISP design when comparing the ratio between the obtained cod reduction and losses of other economical important species. Table 4 below summarises the results of these trials showing the differences by value and weight of the retained catches compared to the standard trawl

Table 4 Total value of the catch in both value and weight over MLS in the Danish whitefish trawl experiments.

SPECIES	DIFFERENCE FSIP		DIFFERENCE LMTP	
	Value (%)	Weight O MLS (%)	Value (%)	Weight O MLS (%)
COD	-78	-76	-38	-43
HAD	-65	-54	-81	-80
HAK	-63	-58	-42	-34
LEM	-50	-46	-59	-51
MON	-73	-53	-8	-17
NEP	4	9	-3	-4
POK	-96	-96	-90	-90
PLE	-29	-23	-15	-17
WIT	-49	-50	-61	-46
Total	-57	-	-36	-

Separator panels

Work with horizontal separator panels were first reported by Main and Sangster in 1982 (Main and Sangster, 1982, 1983). These experiments showed that it was possible to separate haddock and whiting from species like flatfish and cod by fitting a simple horizontal panel of netting inside the trawl. The separating panel was rigged at an appropriate height inside the trawl with its fishing line directly above the footrope and terminated in two independent codends (See Figure 6 below).

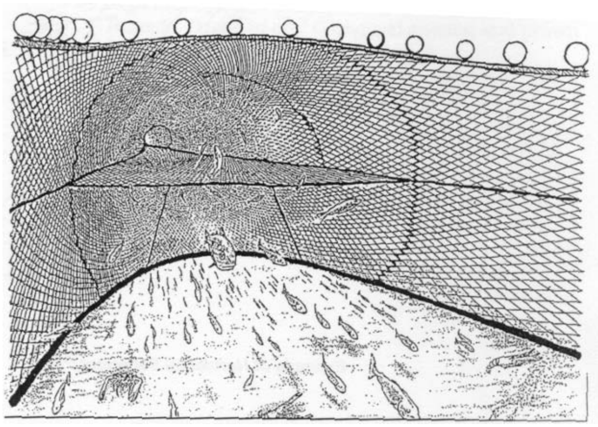


Figure 6. Horizontal Separator Panel

Other work with horizontal separator panels to sort cod from other species such as haddock and whiting is reported in Section 6.3 but it is worth noting that similar horizontal type separator panels have been experimented with to improve selection of American plaice (*Hippoglossoides platessoides*) and cod. These panels were designed to use behavioural differences between the species to select them as they entered the trawl and travel toward the codend. In these experiments reported by Hickey *et al.* (1998), a separator panel was installed at four different heights above the footrope. The separation of plaice and cod, however, with this method was found not to be commercially acceptable. The authors concluded that to prevent high losses of commercial size plaice it would have been necessary to have a separator panel height which would result in over 50% of the cod being retained (Table 5). Yellowtail results outlined in Table 5 below were virtually the same as plaice. These results suggested that using horizontal separator panels alone would not solve the cod bycatch problem on the southern Grand Banks. However, Hickey and Brothers also suggested, the positive aspects of this device could very well be enhanced when used in combination with methods such as rigid grates or grids, square mesh or large mesh etc.

Table 5. Percentage of catch in a separator trawl (above & below separator) with the separator at 97cm above the footrope.

SPECIES	TOP			BOTTOM			TOTAL CATCH
	%of total catch	Length Range (cm)	Mean Length(cm)	%of total catch	Length Range (cm)	Mean Length(cm)	
Cod	49	20-113	45.9	51	19-128	45.3	1678
Plaice	7	15-63	35.0	93	12-64	34.3	866
Yellowtail	8	23-49	36.9	92	17-48	34.9	336

Rigid Grids

Selection grids (Figure 7) are used to improve species selectivity in many tropical and temperate shrimp trawl fisheries and are mandatory in many fisheries worldwide (Broadhurst and Kennelly, 1996; Watson *et al.*, 1986; Mounsey *et al.*, 1995; Isaksen *et al.*, 1992; ICES, 1998). Grids exploit size differences between the target and unwanted bycatch species. The bars of the grid prevent the passage of the larger fish, which are guided up and out of an escape hole.

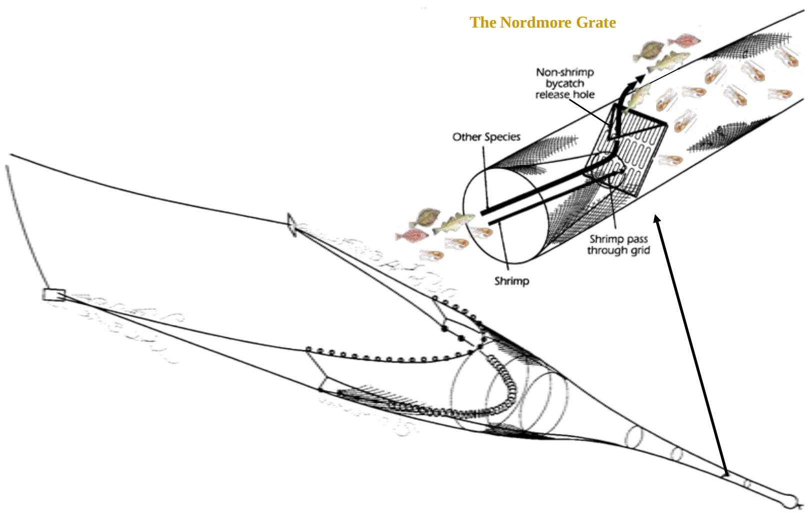


Figure 7. Typical shrimp selection grid used in shrimp fisheries throughout the world.

The following details specific experiments with grids to sort cod from flatfish. Other studies to sort cod from other species using grids are reported in Section 6.5.

Hickey *et al.* (1995) conducted two commercial trips, in June and December 1994, to assess the suitability of Nordmøre style selection grids to separate cod and flatfish in the Southern Grand Banks (Figure 8). The grids were installed in the extension and were made from stainless steel, measuring 1.5 x 1.5 m with either horizontal or vertical bar spacing; a guiding panel was also inserted as used commonly in shrimp fisheries.

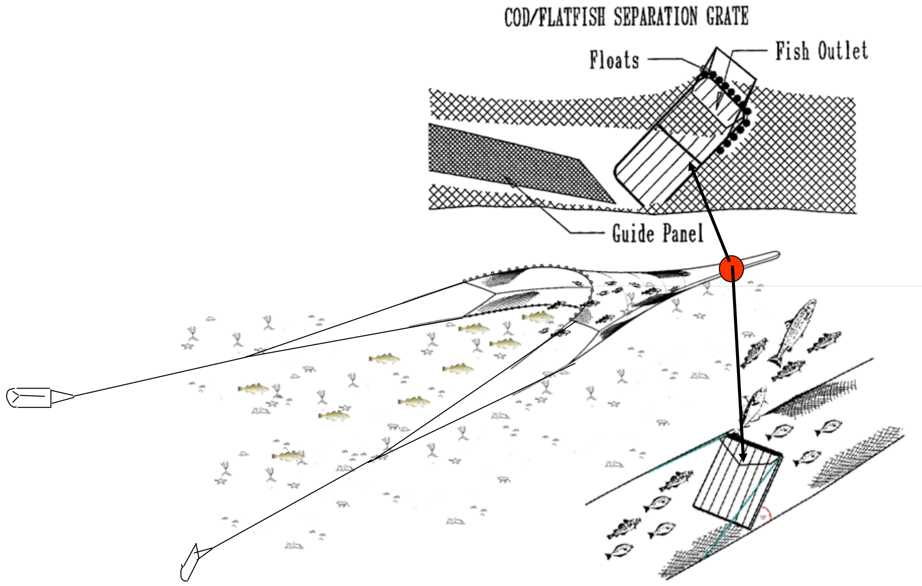


Figure 8. Selection grid used in trials by Fisheries products International in conjunction with Dept of Fisheries & Oceans and Fisheries & Marine Institute of Memorial University to reduce cod bycatch in flatfish trawls.

The trials showed that a horizontal bar spacing of 102 and 72 mm gave almost 100% exclusion of cod but also a large loss of flatfish. Grids with vertical bar spacing of 127mm gave 84% cod exclusion and 8% loss of plaice, suggesting that flatfish are more inclined to pass through grids with a vertical bar orientation rather than horizontal bars. It was also noted that grid angle and the shape of the fish outlet at the top of the grid had an influence on effectiveness. Overall a vertical bar spacing of 127mm, reduced cod catch to less than 5% whilst minimising flatfish loss to around 10%. The cod retained tended to be larger than the ones escaping. Using a rectangular escape outlet in place of a triangular one did reduce flatfish loss, while larger grid angles reduced loss of yellowtail with little change in cod loss. These increased grid angles were also more susceptible to blockage. Having a water flow sensor allowed blocking to be detected and could usually be alleviated by altering the towing speed up and down. Following the trials, 27 commercial boats from the company involved, FPI, fitted their nets with grids with vertical 140 mm spaced bars for use fishing in grounds with high cod bycatch. FPI has undergone many changes since then and now has new owners. It is not known if they are still using these grids. The results from these trials are summarised in Table 6 below.

Table 6. Summary of results obtained with modified Nordmøre Grids showing exclusion rates.

Grid spec (Bar Spacing & Angle)	Escape opening shape	Cod	Plaice	Yellowtail	Greysole	Codend	Escapes
				Horizontal Bars			
102mm, 58°	△	98% (0.7)	31%	38%	33%	48cm	99cm
76mm, 67°	△	95% (0.4)	45%	48%	42%		
				Vertical Bars			
127mm, 67°	△	88% (3.6)	9%	10%	7%	90cm	45cm
127mm, 78°	▯	90% (3.8)	17%	16%	12%	53cm	38cm
127mm, 65°	▯	85% (0.5)	8%	7.5%	7%	76cm	44cm
163mm, 67°	▯	52% (29)	4%	4%	2.5%	84cm	45cm
152mm, 68°	▯	58%	9%	16%	9%	44cm	36cm

Michael and Lee (2009) reported on similar work with a Nordmore style grid and an escape vent fitted into a standard groundfish trawl. The purpose was to develop a net that would allow flounder to pass through a grid to the codend, but direct cod upwards and out of the net. The gear was tested and videotaped in shallow waters in Ipswich Bay, Massachusetts. The original grid design had horizontal openings of decreasing size from an aperture of 10″ at the bottom to 2″ inches at the top and was inclined towards an escape vent at the top of the net. This design proved unsuccessful, since a significant amount of cod passed through the grid during the first few trials. Further modifications were made to improve separation and as a result an optimal design using a steel grid with horizontal bars spaced 3″ apart, produced a 73% reduction in the number of cod caught on the grate or in the codend and a 12% loss of flounder out of the escape vent. Clogging of the grid by large monkfish and dogfish was found to be problem. The authors identified a possible solution by using a ventral escape vent for monkfish.

This approach was evaluated in a further study reported by He (2002) that analyzed a more complicated double-grid system. This project involved the design, flume tank testing, and sea trials of various grid devices to separate species of groundfish during trawling andincorporated designs to suit the condition for the Gulf of Maine and Georges Bank multispecies fisheries. The grids utilized differences in shape and behaviour between flatfish and cod, and aimed to improve size selectivity of flatfish and reduce cod bycatch in flatfish trawls. Modifications were made using flume tank testing and sea trials. Three sea trials were carried out between October 2001 and August 2002. Selectivity devices tested at sea included High Density Polyethylene (HDPE) gird and stainless steel grid, with both horizontal grid bars and vertical grid bars, and with the grid oriented forwards and backwards (See Figure 9 below). The final (roller grid) version tested also incorporated a large opening on the bottom for release of monkfish and skate. During these tests, the grid was installed on a frame for easy installation and grid angle adjustment. Stainless grids replaced HDPE grids in more recent sea trials due to better handling and easier modification on board the fishing vessel. A total of 66 two-hour tows were made using the control (commercial) trawl and the experimental trawl with grid selectivity devices. Thirty-nine tows were monitored with an underwater video camera at the selectivity device. The amount of catch and catch composition varied greatly among locations and time of the year, and between tows and only on one trip on the north side of Georges Bank were reasonable amounts of cod and flatfish mixture encountered. The results, therefore, were somewhat inconclusive but showed that a 105 mm horizontal roller grid had potential for separating roundfish from flounder, while a 90 mm roller grid and a 90 mm diagonal grid had potential for size selective harvesting of monkfish. While statistically insignificant due to a small number of tows, the latest version of grid, the 90 mm spacing Roller Grid seemed to reduce cod and haddock catch considerably. However, losses of large number of flatfishes through the opening on the top of the grid were also observed.

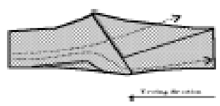
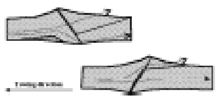
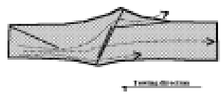
Grid type	HDPE GRID	STEEL GRID	STEEL ROLLERGRID
Grid spacing	90 mm	80 mm	80 mm/90 mm
Orientation	vertical, slanted forward	vertical/horizontal, slanted forward/ backward	horizontal, slanted backward
Other details	with mini grid of 50 mm spacing in front	also with hinges for angle adjustment	also with large opening on the bottom for skates/monkfish
Sketch			
Tested	Oct. 2001	April/May 2002	Aug. 2002

Figure 9. Details of the grid devices used.

Zacharissen (pers. comm. 2009) reports on work with grids in the Faroe Islands. In the summer months small Faroese trawlers (20 m – 25 m) are granted special licenses to trawl for flatfish inside the 12 mile limit. Since 1997 the use of a sorting grid has been mandatory in this fishery. The aim is primarily to reduce the bycatch of cod and haddock. The system comprises of a sorting grid and two codends, as shown in Figure 10. The size of the sorting grid is 1,40 m x 1,40 m. The bar space is 40 mm and the bars are horizontal. The angle of the sorting grid is 50º–60º, which is greater than used with the Nordmore grid (usually 45º). The lower codend behind the sorting grid has a mesh size of 120 mm and the upper codend has a mesh size of 180 mm.

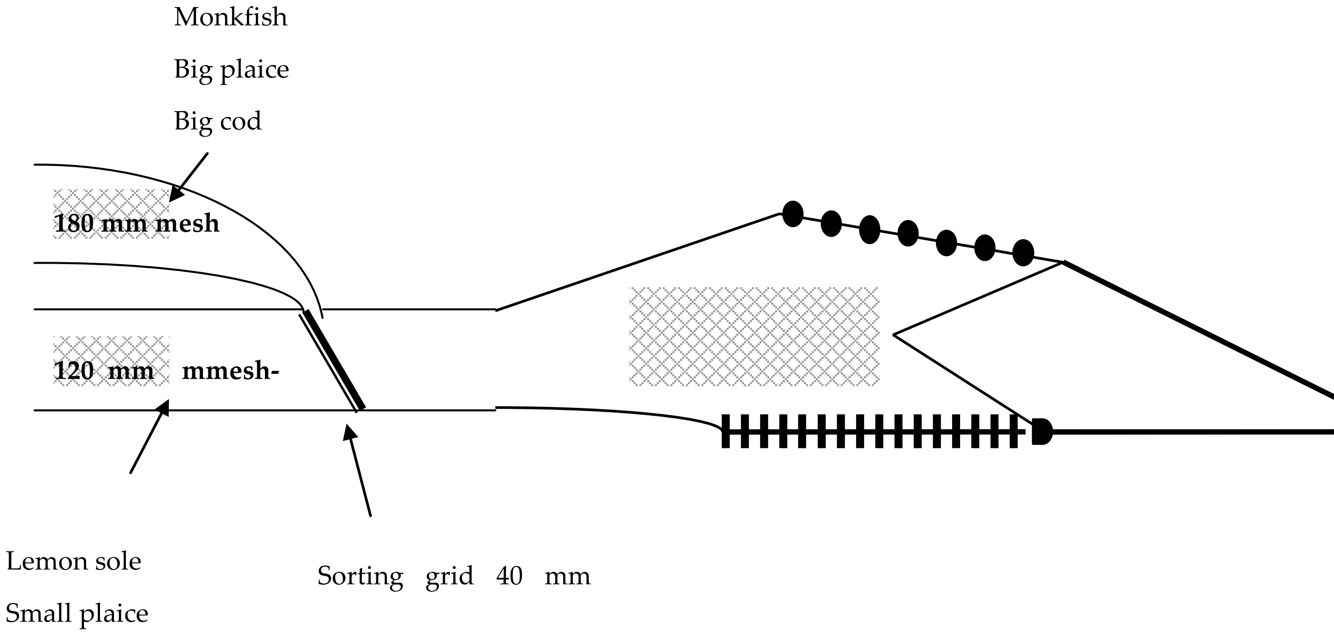


Figure 10. Faroese Flatfish Grid.

In the lower codend, through the sorting grid, enter all lemon sole and small plaice. All other fish, which cannot pass through the grid, enter the upper codend with a mesh size of 180mm inside. In this codend all the smaller round fish are size selected through the meshes whereas monkfish and big plaice are retained. Table 7 below show the results from experiments in % terms of catch composition with and without the sorting grid system as reported by Zacharissen. Although not altogether clear they suggest that the grid retains a larger proportion of lemon sole, plaice and monkfish than the standard trawl, with a reduction of cod and haddock catches.

Table 7. Catch compositions with and without Faroese grid fitted.

Species	% Retained without Grid	%Retained with grid
Cod	43.9%	22.1%
Haddock	26.5%	0.6%
Lemon Sole	13.1%	16.1%
Plaice	2.9%	31.5%
Monkfish	5.1%	22.8%
Others	8.5%	6.5%

Square, Composite mesh and T90 codends

As reported by Madsen (2007) codends with square meshes in the entire codend have been extensively tested in gadoid fisheries in a number of areas to select cod from other species based on differences in shape of target species and bycatch species. In tests carried out in the Georges Bank cod fishery by Hickey *et al.* (1993), it was found that large square mesh codends can be useful in reducing cod bycatch in areas of mixed cod and plaice populations but only when cod less than 60cm predominate. If cod are extremely large, as was experienced during these experiments, the square mesh size required to exclude them would also release unacceptable amounts of commercial size plaice and yellowtail flounder. Larsson *et al.* (1988) reports similar results in trials in the Baltic Sea cod fishery with a 5m long square mesh codend. This work showed that catches of cod above minimum landing size were almost identical whereas substantially more undersized cod were caught in a standard trawl. Madsen (2006) concludes that the square mesh codend was never found to be acceptable in many commercial fisheries because the loss of flexibility in the netting makes the codend difficult to handle and more sensitive to breaking with large catches. It has also been reported by Robertson and Stewart 1988 that square mesh codends are only useful in size selecting for cod and other gadoid species, flatfish are poorly selected by square mesh.

Taking this on board, Glass (2000) considered the use of composite codends made of square and diamond mesh, with the square mesh hung as a panel in the top part of a diamond mesh codend (Figure 11). Five different composite mesh codend configurations were tested, two of which showed promise during sea-trials, to determine their effectiveness in reducing bycatch and discard of key species. The codends were comprised of different configurations of 6″ and 6.5″ square and diamond mesh. Testing occurred using three different fishing vessels operating in different areas and at different times of year. Most sea trials were conducted using alternate tow techniques. Videotape recordings of fish reaction behavior were be made throughout the duration of the program and later used to develop more effective species specific selection devices. The investigators found differences in the selectivity of the different codends used. Composite mesh was effective in significantly reducing bycatch and discard of a range of groundfish species, including cod. These preliminary trials, while demonstrating great promise (e.g. a 62% decrease in capture of sub-legal cod when employing a composite mesh codend), also indicated seasonal variation in degree of effectiveness. Further work was carried out in 2002 to test the effectiveness of two novel, composite mesh codends (constructed with the proposed increased minimum mesh sizes, 6″ and 7″ diamond and 7″ square mesh netting) in Gulf of Maine groundfish fisheries. Their selective efficiency was compared with codends constructed with current minimum mesh sizes (6″ diamond and 6″ square) and projected minimum mesh sizes (6″ diamond and 7″ square). Hexagonal meshes of 6″ mesh size were also looked at for a short period (Glass *et al.*, 2009). Project results formed the scientific basis of allowing the use of composite mesh codends in Amendment 13 to the Northeast Multispecies FMP and it is reported that several New England fishermen have since used composite mesh commercially.

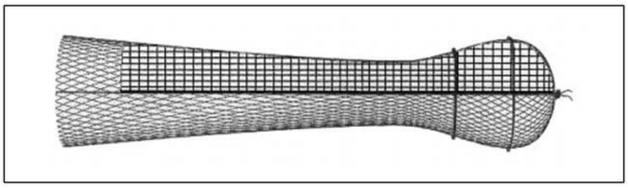


Figure 11. Composite codend showing square-mesh netting covering the top portion of the codend and diamond-mesh netting on the bottom half.

Trials with codends with side panels of square mesh inserted are reported in Commercial Fishing News (2006). The trials were carried out on the Georges Bank in 2003 and tested a four panel codend of 6″ diamond mesh with 6″ square mesh side panels inserted the full length of the codend and 15 bars deep. This net was tested against a standard New England groundfish trawl with a 6″ diamond mesh codend over 21 pairs of alternate tows. A second set of trials were carried out but the taper in the belly section of the trawl was cut down to 5:1 in an attempt to stimulate escape behaviour by cod and haddock. The square mesh side panels were kept the same in these trials and a total of 19 pairs of twos were completed with this option. The results showed the first experimental option to be the best with a reduction of 95% of undersized cod; 96% of undersize haddock and no reduction in catches of dabs, grey sole, monkfish, hake or skate. The experimental net did catch more market size cod but the catches were not significantly different and also caught less marketable haddock. The conclusion from this work was that while the escapement appeared to be a positive sign for the sublegal fish, the loss of marketable haddock (~78%) would likely be a problem for fishermen.

In a number of fisheries codends where the standard diamond meshes are turned 90º (T-direction, often referred to as T90) have been tested notably in Poland (Moderhak, 1999) and Germany (Wienbeck and Dahm, 2000). T90 codends are now regulated for in the Baltic Sea cod fishery and selectivity data suggest them to give similar or better selectivity for cod than square mesh codends or composite codends. However, there are still questions about the stability and strength of T90 meshes. There is no evidence of them being selective for flatfish.

Large square mesh panels

An alternative to using square mesh or composite codends is to use a square mesh panel or "window". The square mesh panel (Arkley, 1990; Madsen *et al.*, 1999) is probably the simplest gear modification that has been developed to improve the selection pattern of trawls in a large number of fisheries, particularly to reduce the retention of undersize haddock, whiting and cod, which are a large proportion of the discards in many mixed fisheries. From a practical perspective, the square mesh panel is cheap and easy to install. Studies have shown that the effectiveness of the square mesh panel depends on its position relative to the codend, but the literature is somewhat contradictory in terms of the optimum panel position. Graham and Kynoch (2001) and Graham *et al.* (2003) suggest that the panel is more effective closer to the codend like the Bacoma window, Suuronen *et al.* (2000), Armstrong *et al.* (1998) suggests that the panel is better placed further forward in the trawl, and O'Neill *et al.* (2006) found that the panel was most effective in a mid-position. It is likely that these differences are largely due to the trawl design. Graham and Kynoch (2001) and Graham *et al.* (2003) used a whitefish trawl, which are generally much larger, with higher headline height and longer extensions (intermediate) than *Nephrops* trawls, with which Armstrong *et al.* (1998) experimented. This suggests that the square mesh panel needs to be tailored to different trawl designs and maybe less universal than the grid system in its application across fisheries.

With respect to specific applications to reducing cod catch, of most relevance are the different types of windows tested in the Baltic Sea cod fishery beginning in the mid-1990s. This fishery has an important bycatch of flounder and other flatfish species. The different designs are reported by Madsen (2007) and include the Swedish style side windows; Danish windows and the Bacoma window (quite similar to a composite codend). Figure 12 below shows the different designs but in testing the Bacoma window has been found to be most effective with no reduction in flounder catches. It should be noted, however, as with the square mesh codend, the current Bacoma panel regulated for in the fishery with a mesh size of 110 mm with a 105 mm codend will only release cod up to 38–40 cm. This mesh size is designed to match the mesh size to the minimum landing size of cod in the Baltic Sea.

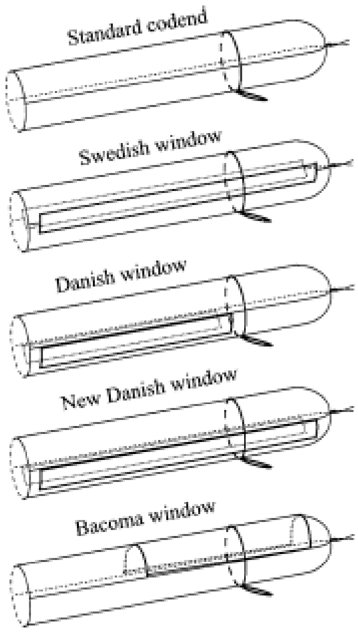


Figure 12. Variations of codend with square mesh windows tested in the Baltic Cod fishery.

Experiments as reported by Valentinsson and Tschernij (2003) have shown a Bacoma 120 mm mesh size gives similar selectivity parameters to a 140 mm diamond mesh. Therefore it is reasonable to assume a Bacoma window in a large mesh size will increase escapement of cod of all sizes while not reducing catches of flounder.

This concept has effectively been tested in recent Danish studies to minimise cod catches in mixed trawl fisheries for *Nephrops* and flatfishes (sole and plaice) in the Skagerrak/Kattegat. This recent work reported by Madsen *et al.* (2008) indicates that a novel four-panel codend design (SELTRA trawl) with large meshes in a square mesh panel 3–6 m above the codline (150, 300 and 400 mm) can improve selectivity of cod significantly with limited loss of *Nephrops* (Madsen *et al.*, 2008). Depending on square mesh size there can be a loss of other commercial fish species like plaice. The escape (i.e. % reduction in catches) through square mesh panels from this study were as follows:

Cod (all sizes)	150 mm square mesh panel:	36%
Cod (all sizes)	300–400 mm square mesh panel:	61–85%
Nephrops (> MLS)	150–400 mm square mesh panel:	1.5–10%.
Plaice (> MLS)	150 mm square mesh panel:	2%;
Plaice (>MLS)	300–400 mm square mesh panel:	>70%
Saithe (> MLS)	150 mm square mesh panel:	36%
Saithe (>MLS)	300–400 mm square mesh panel:	> 90%

This work is ongoing and further testing to find the optimal mesh size to provide a balance between reducing cod catches and maintaining catches of other marketable species is continuing.

Modifications to Beam Trawls

While perhaps not directly applicable to trawl fisheries, the group felt it useful to report the results from extensive testing of devices to reduce cod bycatch in the Belgium and Dutch flatfish beam trawl fisheries given many of the same principles of cod and flatfish behaviour were used in developing these gears.

Belgian Studies

During an EU funded project, SOBETRA (Optimization of a species selective beam trawl) (Fonteyne, 1997) ILVO-Fishery tested a number of gear modifications aimed at reducing the roundfish bycatch in the Belgian flatfish beam trawl fishery. These designs consisted of the creation of large escape zones for roundfish in the top panel of the trawl without affecting the catch of flatfish and are reported by Depestele *et al.* (2009). Two types of escape openings were tested, viz. square mesh top panels and cutaway covers. The square mesh top panels were made of traditional diamond mesh netting with a mesh opening of 120 mm. The remaining diamond mesh sections also had a mesh opening of 120 mm. The netting was stretched in the direction of the bars and heat-set prior to the construction of the cover.

The cutaway covers were easily constructed from the conventional top panels by cutting away the excess netting and reinforcing the new front edge. On a number of occasions the cutaway covers were provided with a square mesh window in the aft part of the top panel. The mesh side was 200 mm; the size of the window was 9 x 15 meshes. Several representative categories of vessels were chosen to test the new designs. A catch comparison methodology was used to compare the performance of each experimental gear with a conventional gear fished simultaneously on the other side of the ship.

Following flume tank testing, separate trials on the three most important Belgium beam trawl sub fleets i.e. 270–300 hp, 600–100 hp and >1100 hp were carried out. The trials showed a mixture of results and the catch reductions obtained with the various configurations as shown in Table 8.

Table 8. Catch reductions obtained with the various configurations (taken from Depestele *et al.*, 2008).

Vessel	Beam length	Configuration	Cod	Whiting	Haddock	Sole	Plaice
221 kW	7 m	Cutaway cover	[-6%]	-13%	No catch	+1%	-6%
		Square mesh top	[+6%]	-8%	[-3%]	-2%	-8
516 kW	9 m	Square mesh top	-5%	-5%	No catch	-18%	-18%
		Cutaway cover with SQW	-4%	-47%	No catch	[-5%]	-13%
684 kW	9m	Square mesh top	-6%	[-30%]	no catch	-5%	0%
		Cutaway cover with SQW	+3%	[-27%]	-41%	[+12%]	+6%
882 kW	10 m	Cutaway cover	+5%	-38%	-24%	+2%	-2%
		Cutaway cover with SQW	[-16%]	-20%	-22%	+1%	-3%
		Square mesh top	-12%	-48%	-43%	-6%	0

The conclusions from these experiments were that the species selectivity of the beam trawls could be improved for whiting and haddock, but much less for cod. This is in accordance with underwater observations showing that roundfish species stay in different levels in a trawl with haddock in the upper level, whiting in the middle and cod in the lower level (Main and Sangster, 1981). Hence, the animals closest to the escape zone in the upper level have more chance to swim out of the trawl before entering the codend. Roundfish species like haddock and whiting, which stay in the middle or upper part of a trawl when they are caught, can escape through escape openings in the top panel of a beam trawl. The efficiency depends on the size of the escape opening and consequently they are only efficient when inserted in the larger beam trawls. Cod, however, even in nets with a very low opening such as a beam trawl, were observed remaining close to the belly of the trawl when caught and took no or little advantage of these escape openings. This is similar to the findings of Pol *et* *al.* (2003) with the "lowrider" trawl, where no difference in cod catch was observed with a very low opening net.

An inclined separator panel, rigged from the chain matrix to the cover, combined with a cutaway cover was also tested to reduce the bycatch of cod. The separator panel was designed to guide cod to the opening in the top of the trawl. An inclined separator panel was tested on board the commercial fishing vessel Z 39 Zuiderzee (32.5 m LOA, 251 GRT, 750 kW). During three fishing trips in ICES Area IVc (May to July 2008), cod catches were recorded per haul and per side, enabling a catch comparison (See Table 9). Limited data was recorded for other species. Over all trips, a consistent and significant reduction of cod catches was observed (-26% trip 1, -42% trip 2, -42% trip 3). Limited catch data was available for other species, showing no significant difference in the catch between both sides (Depestele, 2009).

Table 9. Catch differences (%) observed with an inclined separator panel

SPECIES	CATCH DIFFERENCE (% WEIGHT)
Cod	-39%
Sole	+0.4%
Plaice	- 6%
Mixed ray	-3%
Whiting	+5%

The results from these experiments suggested that application of an inclined separator panel in a beam trawl can significantly reduce unwanted bycatch of cod (-39%). The limited data available on other species showed no significant catch reduction. In a previous experiment carried out in 2005 within the framework of the REDUCE project (Anon. 2002a), a 20% catch reduction was observed for cod. Catch reductions were also observed for whiting (20%) and haddock (30%). The differences observed may be explained by differences in rigging.

Dutch Beam Trawl Studies

Van Marlen (2003) reports the results of similar experiments aimed to improve the selectivity of beam trawls in the North Sea for roundfish whilst minimizing losses of target flatfish. Large-meshed top panels were designed for the tickler chain type of beam trawls used in this fishery (V-nets). The design process involved model studies in a flume tank, feasibility trials at sea on a research vessel, and comparative fishing trials on chartered commercial fishing vessels. A total of 11 weeks with 450 hauls in total were fished on two categories of vessels, namely 300 and 1500–2000 hp, representing the major groups in the Dutch fleet. Table 10 shows the different options tested.

Table 10. Trip overview (taken from Van Marlen, (2003)

Table 2
Overview of trips

Trip	Vessel ID	Vessel name	hp	Period	No. of hauls	Gear	Configuration
1	OD-1	Maarten Jacob	2000	November 1994, 114 valid	44	V-net, 12 m	LMT 1
2					32		
3					38		
4	WR-23	Vrouwe Geertruida	300	April 1995, 112 valid	43	V-net, 4 m	LMT 2
5					31		
6					38		
7	UK-284	Cornelis Zeeman	1500	June 1995, 47 valid	47	V-net, 12 m	LMT 1
8	OD-1	Maarten Jacob	2000	March 1996, 118 valid	40	V-net, 12 m	LMT 3
9					48		
10					47		
11	UK-284	Cornelis Zeeman	1500	June 1996, 128 valid	42	V-net, 12 m	LMT 3
12					41		
13					42		

A reduction of 30–40% for cod and whiting could be obtained with the new gear design, with virtually no losses in flatfish (particularly sole and plaice), Figure 13 below shows the best design tested, while Table 11 summarises the results obtained from the different trials.

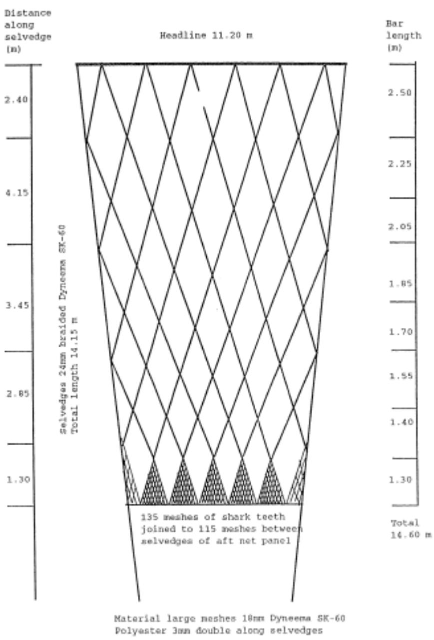


Figure 13. Final design of Large Mesh Top panel (van Marlen, 2003)

Table 11. Data showing differences in total catches landed (from Van Marlen, 2003)

Table 4
Differences in total catches landed (boldface = significant)

Species	Trip					
	OD-1, 1994		WR-23, 1995		OD-1, 1996	
	LMT/CON (%)	*P*-value	LMT/CON (%)	*P*-value	LMT/CON (%)	*P*-value
Cod	**66.61**	**0.0001**	**56.42**	**0.0001**	**59.39**	**0.0001**
Whiting	**80.56**	**0.0031**	**68.80**	**0.0001**	**94.63**	**0.0001**
Turbot/brill	**73.73**	**0.0001**	**74.02**	**0.0001**	96.34	0.4588
Sole	93.65	0.3689	91.45	0.1880	101.89	0.7100
Plaice	93.59	0.3640	83.69	0.0087	93.91	0.2114

Although fish behavior inside these trawls could hardly ever be observed, due to sand clouds inside the net generated by the tickler chains (van Marlen *et al.*, 1993; Fonteyne., 1997), the results confirm the hypothesis that whiting and juvenile cod orientate towards the top panel, and flatfish remain closer to the lower panel. In many observations, however, mature cod did not show a strong escape reaction, although these were mainly done at lower towing speeds, much lower than the attainable burst speed of these fish, and also lower than the normal towing speeds used in beam trawling. A comparison between various types and dimensions of beam trawls and towing speeds suggests that a relatively long escape section and lower towing speed gives the roundfish more escape opportunities (Fonteyne., 1997).

In the Dutch V-net designs a section of about half the length of the trawl was showed to be effective. The top panel was also tried in chain mat round nets with some success, be it to a lesser extent than in V-nets. In two weeks fishing on a commercial beam trawler using chain mat gears in December 2003 cod landings could be reduced by some 25%–30% using a large mesh top panel with 1200 mm mesh (twine thickness 16 mm), but the penalty was a loss in target fish (sole and plaice) between 5% and 10% .

Gear modifications developed to sort cod from other species

There is a large amount of research into gears that have been developed to separate cod from other species such as haddock, whiting, *Nephrops* and shrimp. Such designs and devices include:

- "Eliminator" style trawls with large meshes at the front
- Raised footrope trawls
- Danish Selective Whitefish Trawls
- Horizontal separator panels
- Inclined separator panels
- Rigid and flexible grids

"Eliminator" Style Trawls with large mesh at the front

Eliminator trawl

The effects of employing a large mesh faced (top, bottom, and side wings) bottom trawl designed to capture haddock while reducing the bycatch of cod as well as other species were investigated by Beutel *et al.* (2008). This experimental net, named the "Eliminator Trawl" by the manufacturer, but it has since been renamed by NOAA to the "Rhule Trawl", exploits the differences in fish behaviour. Two commercial vessels conducted parallel comparison hauls with one vessel towing the control net and the other towing the experimental net. A total of 100 successful tows were completed. The "Eliminator Trawl" significantly reduced the catch of stocks of concern including cod, yellowtail flounder, winter flounder, witch flounder, and American plaice. Other species such as monkfish and skate also showed significant decrease in catch in the experimental net. In addition, the catch of haddock, the target species, did not differ significantly between nets.

The overall rounded ratio of haddock to cod from the control net was 3:1 which was improved in the experimental net to 20:1. The ratio of haddock to yellowtail flounder was 13:1 and 151:1 for the control and experimental nets, respectively. The winter flounder ratio was 1:1 for the control net and 19:1 for the experimental net. For the control net, the number of skate was greater than the number of haddock with a 0.66:1 ratio whereas for the experimental net, the ratio was 56:1. No differences were found of the weights caught of haddock, pollock (*Pollachius virens*), Atlantic herring (*Clupea harengus*), silver hake (*Merluccius bilinearis*), red hake (*Urophycis chuss*), illex squid (*Illex illecebrosus*), and loligo squid (*Loligo pealeii*). For cod, yellowtail flounder, winter flounder, witch flounder, American plaice and many other species, there was a significant difference in the catch weights between the control and the experimental nets.

Revill (2007) reports of trials with a similar "Eliminator" trawl in the North Sea. The objective of this trial was to compare catch composition attainable with this trawl in a mixed demersal fishery and specifically whether cod catches could be reduced. The trials were carried out as a parallel haul experiments with two vessels towing in close proximity. The results indicated that the "Eliminator" trawl could be used to selectively target haddock and whiting. Very few other species were caught compared to the control trawl. Catches of cod at all lengths were around 90% less than the quantity caught in the standard control trawl. The "Eliminator" trawl also caught 83% less unwanted fish of a variety of other species including gadoids, rays, flatfish and gurnards.

Scottish belly trawl

Similar work has been ongoing in Scotland. Recent trials reported by Kynoch *et al.* (2009) trials took place in Scotland on two commercial vessels, the Caspian (BF 38) in June 2008 and on the Genesis (BF 505) in December 2008. These trials aimed to identify whether incorporating 800mm diamond mesh panels in the trawl's belly sheet of commercial trawl nets can provide an escape route for cod but still allow other commercially important ground fish such as monkfish, megrim and lemon sole to still be retained (Kynoch *et al.*, 2009). Three different configurations were considered. The Caspian trials investigated two of these cases. In the first, an 800 mm diamond mesh panel was inserted into the first belly section of the trawl, while in the second an additional 800 mm panel was inserted into the belly section immediately behind the first one. The Genesis trials investigated a third case which consisted of two 800 mm diamond mesh panels inserted into the sides of the of the trawls belly section.

There was no loss of catches of haddock and whiting in any of the three test gears and no loss of cod when using the first gear of the Caspian trials. The sand cloud produced by the tickler chain obscured the centre section, the quarters of the fishing line and the middle of the 1st belly panel and may explain why no cod were lost through this panel. In contrast the 2nd panel was reasonably clear of the sand cloud and there was length dependent selection for cod in this gear and the gear tested on the Genesis. The relative catch rate of the second Caspian gear increased from about 36% for 32 cm fish to 56% for 77 cm fish; while that of the Genesis gear increased from about 15% for 32 cm cod to 42% for 49 cm cod. There was also evidence of losses of monkfish and megrim through these latter two gears: for megrim the relative catch rate of the two panel Caspian gear increased from an estimated 12% for 24 cm fish to 31% for 48 cm fish and was significantly less than unity for all lengths; and for monkfish the relative catch rate of the Genesis gear increased from 24% for 36 cm fish to 48% for 66 cm fish, but was only significantly less than unity for lengths less than 58cm.

Orkney Cod Avoidance Trawl

Campbell (2009) reports on trials with a trawl gear which has become known as the 'Orkney Gear'. The trials compared the gear of that normally towed by the Scottish commercial vessel MV Russa Taign K 1102 with a modified version of that gear where the 160 mm mesh size netting in the forward sections (the belly section, the two panels in the top section and the wings) of the gear was replaced with 300 mm mesh size netting.

The relative catch rates of the modified (test gear) and the unmodified (control gear) of cod, monkfish and megrim differed significantly from a constant relative catch rate of unity. The relative catch rate of cod was length dependent with the test gear catching an estimated 45% fewer cod at 35 cm and 19% fewer cod at 80 cm. The reduction in cod catches was significant for lengths up to 78 cm. The relative catch rate of monkfish was also length dependent with the test gear catching an estimated 37% fewer monkfish at 37 cm, but with no significant reduction in catches for lengths above 55 cm. The relative catch rate of megrim did not depend on length, with the test gear catching about 40% fewer megrim at all lengths. For whiting, there was no evidence of any difference between the control and test gears whereas for haddock 13% more were caught by the test gear than the control.

Raised Footrope Trawls

A semi-pelagic, raised footrope haddock trawl, called the 5-point trawl, was tested on Georges Bank, USA by Chosid *et al.* (2007) to reduced bycatch of cod while maintaining haddock catch. A three-bridle, four-panel box trawl was designed and flume-tank tested collaboratively with a net-maker. Bottom contact is limited to five "drop-chains" that hang from the fishing line. The overall opening of the net has a footrope to headrope height of approx. 8–11 m with the footrope approx. 1.5 meters off-bottom, taking advantage of fish behaviours: haddock generally rise up while being pursued by the net whereas cod tend to rise more slowly, and are passed over without contacting the net. The experimental trawl demonstrated a 98% reduction in cod bycatch compared to a standard trawl in the combined twin and alternate trawl tows; haddock catches were lower in the experimental net although there was no significant difference with the control net's catch; other bycatch species' catch were greatly reduced.

He and Balzano (2008) conducted an experiment on a raised-footrope haddock trawl with varying footrope height. The experiment compared drop chain length of 1.01 m and 1.52 m with the control net with drop chain length of 0.15 m. Preliminary results from sea trials indicates that a 1.1 m drop chain rigging with 49 floats has the best potential of reducing cod catch (by 63%) while maintaining haddock catch (reduced by 9%).

Horizontal separator panels

Horizontal style separator panels have been tested to sort cod from flatfish as reported in Section 5.6, but have more commonly been used to sort cod from other species such as *Nephrops* and other gadoids. For completeness some of this work is reviewed below.

Main and Sangster (1985) reported on trials with a standard fish/*Nephrops* dual purpose trawl re-rigged with a horizontal separator panel which divided the net into two horizontal compartments with separate codends. The prime function was to separate haddock and whiting from *Nephrops* and groundfish (cod, flatfish and skates) during trawling. Diving scientists, using a towed underwater vehicle, observed, measured and when necessary adjusted the gear to obtain the most favourable arrangement during normal towing conditions. Catch figures of whitefish and *Nephrops* in both codends were examined using 50, 70 and 85 mm mesh separating panels set at different heights above the sea bed. A 70 mm separator panel set 75 cm above the footrope of the fish/prawn trawl achieved good separation of haddock and whiting from *Nephrops* and groundfish like cod, flatfish, dogfish and skates.

Rihan (1995) reports on trials carried out on the north-west coast of Ireland with a similar horizontal separator panel. These trials yielded encouraging results with high vertical separation of haddock, whiting and to a lesser extent hake into a top codend from flatfish, cod, rays and monkfish retained in a lower codend. The trials also illustrated that there is considerable scope for the separator trawls be used to improve the selectivity of towed gear in mixed fishery situations by increasing mesh size in one or other of the codends and by the installation of square mesh panels. The horizontal separator panel was constructed as per the earlier trials by Main and Sangster (1982; 1985) and was identical to the corresponding top sheet sections of the net in terms of both shape and cutting rates. It was mounted onto its own light frame rope and incorporated into the net as an independent selvedge to allow easy repair or removal. At the end of the separation panel double codends were attached in the form of a figure of eight allowing clear passage of fish into top and bottom codends. Both codends had a mesh size of 80 mm I.M., with the top codend some 2m shorter than the bottom codend to limit any masking of the lower codend meshes by the upper codend due to their relative positions. The separator panel was set at a height of 0.75m (2.5 ft) at its leading edge. This was achieved by the use of light retaining ropes attached to the quarters of the panel and fishing line. Table 12 below summarises these results:

Table 12. Separation rates achieved by species.

	VERTICAL SEPARATION %			
	Below MLS		Above MLS	
Target Species	Top Codend	Bottom Codend	Top Codend	Bottom Codend
Haddock	84.26%	15.74%	83.75%	16.25%
Whiting	67.50%	32.50%	92.14%	7.86%
Cod	9.34%	90.66%	21.18%	78.82%
All Flatfish	5.81%	94.19%	2.84%	97.16%
Rays	15.86%	84.14%	11.63%	88.37%
Monkfish	0	100%	0.27%	99.73%

Cotter *et al.* (1997) and Arkley (1995) both describe the separation ratio into upper and lower compartments of commercial trials with separator trawls, aimed at segregating cod from haddock and whiting. Cotter *et al.* (1997) report on a series of trials conducted in the Moray Firth during November 1994 and off the North English coast in March 1994. Consistent separation rations were obtained during both trials during both day and night hauls, no difference being noted. During the trials in the Moray Firth, an average of 87% (range 74–96%) of cod was retained in the lower codend with 20–24% of the haddock and all flatfish. The separating panel was inserted directly above the bosom of the fishing line in a four-panel trawl.

Engås *et al.* (1998) conducted a series of experiments in the Barents Sea with a separator trawl. The cruises were either conducted in full darkness (winter cruise) or daylight/twilight (summer cruise) due to the trials being conducted at high latitudes. Hauls were conducted in deep water (150–280 m). No significant difference in separation rates were observed between the winter and summer experiments for haddock and saithe, ~89 and 66% respectively being retained in the upper codend. A marginally significant difference in separation of cod between the spring/summer and winter cruises was noted. A mean separation rate of 64% in the winter compared to 71% in the summer. Some observations were obtained without artificial light, fish were seen entering the trawl at all levels, but the majority were seen entering at relatively low levels. The separating panel was inserted so as the separator bosom began 30.5 meshes (165 mm full mesh) behind the bosom of the main trawl. It is considered that this 'setting back' of the panel edge is necessary to allow haddock to rise up above the panel. The separator was constructed from square mesh with a bar length of 150mm. This construction was chosen so as to allow any haddock entering low into the trawl the opportunity to penetrate the panel meshes and enter into the upper codend. It is noted that with the exception of cod, no difference in the mean length was noted between the upper and lower codends, however, for cod, during the majority of hauls, significantly larger cod were noted in the lower codend, this may be attributed to the ability of smaller cod being able to successfully penetrate the horizontal panel, possibly suggesting that cod will try to penetrate upwards further back in the trawl. Alternatively, smaller cod encounter the trawl at a higher level and pass over the top of the separating panel.

Ferro *et al.* (2007) described a project to develop species-selective trawl gear to improve the exploitation pattern of North Sea cod, while maintaining the catch of other important commercial species. A gear suitable to the Scottish mixed whitefish fishery was fitted with a horizontal panel in the tapered part of the net to separate species into an upper and lower compartment. Trials were conducted on research vessels to measure separation performance for nine species in different light conditions, at different towing speeds, and with different lengths of panel. Most haddock, whiting, and saithe pass above the panel, whereas most cod, flatfish, and monkfish pass below it. Towing speed and panel length had no significant effect on separation. The percentages of the fish catch which have been separated into the 'upper compartment' using the separator trawl were as follows: cod 1–63%, saithe 73–97 %, haddock 74–95%, whiting 40–95%, lemon sole 1–40%, and monkfish 0–50%. At lower light levels during the night, fewer dab, sole, plaice, and cod passed below the panel. Observations and measurements of fish behaviour using acoustic methods suggested that the height at which fish enter the net mouth may be influenced by light level and water clarity.

He *et al.* (2008) tested a separator trawl to catch haddock while reducing the catch of cod in the Gulf of Maine multispecies fishery. The key feature of the new trawl was the use of ropes, instead of netting, for the horizontal separator and an exit hole behind the fishing line for releasing cod, flounders and other bottom-dwelling species. The sea trials were conducted on board a commercial fishing vessel with thirty six comparative tows (18 pairs) made with the new rope separator haddock trawl with a commercial multispecies trawl. The average catch rate of haddock from the rope haddock trawl was 212 kg/h while that from the commercial trawl was 246 kg/h. The new trawl reduced cod catch by 61%, with an associated reduction in haddock of 16%, both in numbers. Catch of flounders was virtually eliminated in the new trawl. There was also substantial reduction in other commercial and discard species such as spiny dogfish (*Squalus acanthias*), wolffish (*Anarhichas lupus*), lobsters *(Homarus americanus*), and skates (*Raja spp*), using the new rope separator trawl.

A separator trawls was tested by Martins *et al.* (2007) to separate cod and haddock on US Georges Bank. A field experiment was designed to examine the feasibility of using a net panel or "haddock separator" placed inside a trawl to reduce the bycatch of cod in the Georges Bank haddock fishery. The expected behavioural pattern of the two species, in which haddock rise when encountering the separator panel and cod swim down, was examined using video technology. The field results showed a significantly reduced cod-to-haddock ratio (11%) in the experimental trawl compared to the control net (43%). However, there was also a concurrent 42% reduction in the catch of haddock in the separator trawl which represents an important economic loss, and was an industry concern.

Inclined Separator Panels

James McDonnell of Gear-Tech, a private consultancy based in Dublin, Ireland, developed an inclined separator panel to sort cod from *Nephrops* to allow vessels to continue to fish in an area in the Irish Sea that was closed to all fishing by the EU in 2001. The separator panel was fitted into a modified extension piece of a standard *Nephrops* trawl into such a manner as to divert cod and other whitefish species coming down the trawl towards an escape hole on top of the trawl. The panel started 50 meshes above the codend with the leading edge approximately 30 cm above the bottom sheet, allowing the passage of *Nephrops* and other species such as monk and flatfish, while the guiding cod, haddock and whiting out of the escape hole (see Figure 14).

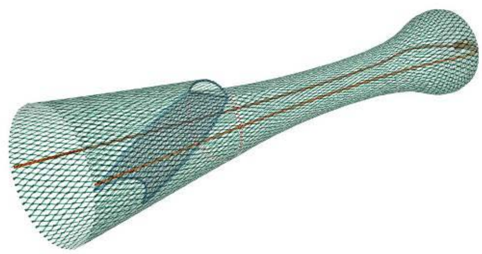


Figure 14. Schematic drawing of the inclined separator panel.

(Images courtesy of Fisheries Research Services (FRS), Aberdeen. Crown Copyright 2004)

Trials in the Irish Sea with the inclined separator fitted to a conventional trawl are reported by Anon (2000; 2002b, 2003; Rihan and McDonnell, 2003). Experiments on both single and twin rig trawlers have demonstrated that the device allows fishermen to operate within bycatch limits set by the EU in this area. Separation of between 65 and 85% for cod is reported over all length classes. Almost all haddock were separated with this device and a large portion of whiting also (over 50%). It is estimated that the trawl fitted with the separator caught 4 times less cod than the traditional trawl. The author compares the result with a conventional horizontal separator trawl and concludes that the inclined version has considerably higher separation efficiency. Previous studies (Dunlin, 1998) achieved separation of 20% by comparison. Additionally, the inclined panel demonstrated good separation of small whiting (+50%) compared to 27% as reported by Dunlin (1998), a similar improvement is reported for haddock, with almost all fish being separated compared to 29-74% (Dunlin, 1998). Similar results were obtained by Hillis (1983; 1984) where a higher percentage of 0-gp whiting were retained in the lower codend.

Galbraith and Mair (unpublished) assessed the effectiveness of the separator in the Clyde in 2001. Three designs of separator were assessed during these trials. An 80mm codend was attached to the escape hole to retain the *Nephrops*/fish that would normally have escaped. Initially, an unacceptable portion of the target species were being lost through the escape hole, so modifications were made to the depth of the separator panel and framing ropes around the leading edge, however, this did not reduce the problem. It was hypothesized that there was insufficient distance between the ground-gear (bosom) and the separator available for the target species to settle back onto the lower bellies of the trawl, a 100 mesh deep extension was inserted to try to alleviate this problem, unfortunately, no improvements were observed. An additional design was tested which included a secondary codend (100 mm); this was intended to retain the legally sized component of the fish entering the gear. The results obtained demonstrated reasonable separation of fish but with economically excessive losses of *Nephrops.* Some indications of size dependency were noted. The results should be treated with some caution due to the low number of hauls obtained and comparisons between the separators complicated due to the differences in designs and the two different mesh sizes used for the upper codends.

Rigid and Flexible grids

Specific examples of grids being used to sort cod from flatfish are reported in Section 5.7, however, grids have also been extensively used to reduce cod catches in other fisheries and some examples of this are reported below.

Graham *et al.* (2004) conducted a series of experiments with a Norwegian 'flexi-grid' system in the North Sea mixed demersal fishery, in order to improve size selection. A dual grid system was installed in the extension of the trawl, with grid angles of approximately 30 degrees, with vertically orientated bars. These trials showed that although size selection of roundfish can be controlled using such a system, a substantial loss of marketable flatfish and other species was noted.

Graham and Fryer (2006) report of follow up trials with a trawl that combined a grid with two codends, as shown in Figure 15 , to separate many species from *Nephrops*, with much of the fish bycatch passing into the upper codend. Discards of fish below the MLS can then be reduced by having a larger mesh size in the upper codend, e.g. 120 mm. The lower codend can be made with the minimum mesh size allowed for *Nephrops* trawls, e.g. 80 mm. The grids were made from solid sheets of nylon (polyamide) 30 mm thick, 1100 mm high and 800 mm wide. Horizontal gaps were machined along the lower edges of the grids to prevent blockages caused by species such as the starfish (*Asterias rubens)* and the sea-urchin (*Echinus esculentus)*. Four grids in all were assessed during the trials, with different combinations of bar spacings, 25 or 30 mm, and lower gaps, 150 or 200 mm. These trials demonstrated the potential for a rigid grid and double codend system to separate the target species, *Nephrops*, from the economically important fish bycatch and to retain the bycatch in the upper codend. A high proportion of *Nephrops* was retained in the lower codend, although the separation of *Nephrops* largely depended on the bar spacing, with more large *Nephrops* passing into the lower codend when the bar spacing was wider. A high proportion of haddock was retained in the upper codend. It is likely that many haddock by-passed the grid, since behavioural studies show that haddock tend to follow the upper parts of the trawl in the area of the trawl mouth (Main and Sangster, 1981). The grid system also separated dab (unfortunately, no other flatfish were caught in reasonable numbers), with 75% of dab being retained in the upper codend and this was considered by the authors to indicate this system may be appropriate for fisheries characterised by significant flatfish bycatch. Few cod were caught during the trials, so the results for cod were considered inconclusive.

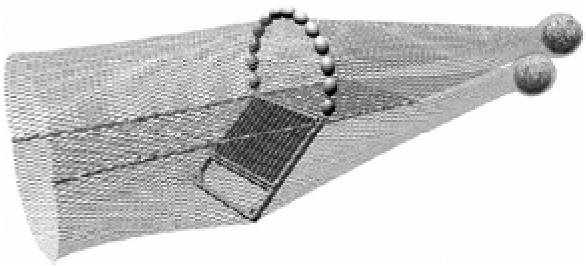


Figure 15. Diagram of the grid and double codend design tested.

(Image courtesy of Fisheries Research Services (FRS), Aberdeen, Crown Copyright 2004).

Valentinsson and Ulmestrand (2006) report on an extensive set of catch-comparison gear tests performed between 2002 and 2006 with Nordmøre type sorting grids in the Swedish *Nephrops* trawl fishery in the Skagerrak and Kattegat. The overall aim was to minimise fish bycatch while maintaining catch rates for the target species, i.e. *Nephrops*. The results showed that a trawl fitted with a grid and a square mesh codend, caught less small and marketable cod, haddock, whiting, hake and plaice than did a standard commercial trawl. For cod larger than 35 cm, the catch reduction was close to 100%. For marketable *Nephrops* no difference in catch amounts was detected.

The results for cod were consistent in all experiments comparing the standard grid with commercial codends. The weight of both discarded and landed cod was significantly reduced with grid-equipped trawls. In all, 855 kg undersized cod was caught with the commercial codends whereas 250 kg were caught when using the grid (71% reduction). For marketable cod, the species-selective properties of the grid trawl were more pronounced as 588 kg cod was caught with the commercial codends. In accordance with Catchpole *et al.* (2006), who compared the Swedish grid in combination with a 70 mm Square Mesh codend to an 80 mm diamond mesh codend, it was found that the grid trawl retained fewer small cod (10–20 cm). The observed reductions of both large and small cod are most likely a result of two interacting selection processes whereby large cod are deflected by the grid and smaller cod escape from the square-mesh codend.

Catchpole *et al.* (2006) reported on a catch comparison method used on a commercial vessel to assess the potential of a similar grid and square mesh codend in reducing fish bycatch, in particular cod, in the Farne Deeps *Nephrops* fishery in the North Sea. A standard trawl with a diamond mesh codend, as currently used in the fishery, was compared against a trawl with a Swedish grid and against a trawl with a Swedish grid and square-mesh codend. The trawl with the grid and diamond mesh codend caught no cod of marketable size and fewer large whiting, plaice and haddock than the standard trawl. However, that grid trawl caught twice the number of small cod and more haddock (and more *Nephrops*), than the standard trawl. The trawl with the grid and square-mesh codend caught less cod, haddock and whiting in all length classes, but *Nephrops* catches were around half that of the standard trawl. Using the grid meant a 75% reduction in revenue from bycaught fish and squid landings, and when combined with the square-mesh codend, a further reduction of 50% in revenue from *Nephrops* landings.

It is also 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 Nordmore grid described previously, it relies more on mechanical separation of species, the 'Sort-X™ grid by providing 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. Both grids have the minimum legal bar spacing of 55 mm. There are a number of studies testing the selectivity of these devices (Larsen and Isakasen., 1993; Jørgensen *et al.*, 2006), which show a bar spacing of 55mm gives equivalent selectivity for cod of 155mm. 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.

Identification of separation in non-trawl gears

The group also discussed separation of cod from other species including flatfish in non-trawl gears, including Scottish seines, gillnets, longlines and pots. A number of pieces of research were found that showed some potential top develop "cod friendly" gears e.g. in Scottish seines and gillnets, and some others that are very much in an experimental phase e.g. longlines and pots where the results may not be directly applicable at this juncture. These gears are reported below.

Scottish Seines

Experiments using an experimental Scottish seine were initiated in 1995, in conjunction with the Responsible Fishing Program at New Brunswick's Caraquet School of Fisheries (Anon., 1997). Over a three year period, trials were carried out on a seine net vessel and tested in conjunction with gear selectivity specialists from Nordsea Limited in Dartmouth, Nova Scotia. The main objective was to sort flounder from cod to allow vessels to continue to fish for flatfish species.

Based on underwater camera footage, its known cod rise up after they enter the seine, and there was some anecdotal evidence that modified seines in Europe had shown decreased cod catches. To take advantage of the upward movement of cod, trials were carried out in 1995 using a seine with the square removed from the top sheet of the net, similar to the work reported earlier by Thomsen (1993). The top sheet was further reduced in trials in 1996 by removing the first top belly. In 1997 more modifications to the top bellies, and evaluation of several experimental escape windows and holes were completed.

The experiments were carried out as a catch comparison exercise using the alternate haul technique. Each seine had 130mm diamond mesh codends and extensions. In the first experiment catches of flounder remained unchanged with the experimental net but with no reduction in cod catches Tows were made in close proximity to one another to ensure similar depth and bottom profile. A standard Scottish seine was used on four other experiments, and included several newly designed escape holes and windows. These were covered and uncovered on alternate tows.

The lack of cod in Gulf area 4Tn forced the evaluation of traditional and experimental nets to be shut down early. Later trips from Cheticamp in area 4T1 allowed underwater video recording of various escape devices using the standard seine. This video footage revealed cod exiting the inline diamond shaped holes in the last belly, and large volumes of fish travelling down the net to the codend. Data also showed that more American Plaice escaped during tows with large volumes of fish. Flatfish escapes were minimal during normal fishing. Fish exiting through such large holes are less likely to receive abrasion than escapes through meshes, and this may reduce mortality rates. An interesting note is how many American plaice swam in a sideways position. They were also seen swimming near the top netting, and trying to escape out the meshes on the top panel.

The final trials in 1997 looked at escape holes cut in the belly section of the seine along with the reduced top panel. Twenty valid tows (ten controls, ten experimental) were conducted. For our pairs of tows the belly escape holes were open, for the remaining six pairs of tows these escape holes were closed. With the escape holes open the percentage of cod escapes from the experimental net was 82%. However, American plaice escapes through the escape holes in the last belly were 42%. These figures are based on four pairs of valid tows and are therefore reported by the authors as only an indicator and it was suggested that a reduction of American plaice escapes could be possible by adding floatation to the escape holes. The losses were seen over the full size range of plaice encountered and were not isolated to small or large fish. When comparing the performance of the control net (normal seine) and the experimental seine with the escape holes covered, very little difference was detected in the catch rates, i.e. 3% less American plaice in the experimental seine, 6% more Cod in the experimental seine. While it is not altogether clear from the report, it would seem that reduction of cod catches in seine nets is technically feasible but must be balanced against potential losses of flatfish species.

Gillnets

Separation of cod from flatfish in gillnets is based upon the same exploitation of vertical height and behavioural differences as with trawl gears. Video camera observations *in situ* of winter flounder showed that the species spent 33% to 68% of time on the substrate (He, 2003). While off-bottom behaviour of yellowtail flounder has been observed at night (Cadrin and Westwood, 2004; Walsh and Morgan, 2004), they usually reside very close to seabed.

Gillnets targeting flounders in commercial practice often are reduced in vertical height through reduced floatation or tie downs. The actual height of the net in fishing conditions, however, is usually less than the maximum as a result of current action and accumulation of catch (Stewart, 1988). Pol (2006) found that experimental reduction of gillnet height through the addition of spaced weights on a foam core floatline and replacement of the floatline with another leadline was effective in maintaining flatfish catch amounts and sizes while reducing bycatch of Atlantic cod by 49% and 58%, compared to standard commercial flatfish gillnets in the Gulf of Maine. Thirty-five sets of experimental gillnets and standard gillnets demonstrated reductions in catch rates of retained and discarded Atlantic cod between designs. No differences were found in catch rates of legal-sized winter flounder and yellowtail flounder among flatfish gillnet designs. Undersized winter flounder catch rates were reduced by experimental designs by 88%. Underwater examination of nets verified that the experimental modifications had lower floatline heights and increased slack in the netting making the gear more akin to an entangling net.

He (2006) tested two low vertical height nets in the Gulf of Maine. The 8 MD experimental gillnets caught significantly less cod than the regular 25 MD net in the Gulf of Maine (He, 2006), while the catch efficiency for flounder (mainly American plaice) was similar. The extended gillnets with an extra 10 meshes of webbing (35 MD) caught significantly more Atlantic cod than the standard 25 MD nets in tests in Newfoundland (Yetman, 1989).

Norwegians use much higher gillnets (60 MD) targeting cod (Engas *et al.,* 2000). Similarly, nets with vertical tie-down lines to reduce vertical profile caught more flounders and other bottom-dwelling animals (e.g. lobsters) but less cod than the standard cod net due to a large amount of slack netting near the seabed (He, 2006). These results indicate that bycatch of cod in flatfish gillnets can be reduced by limiting floatation in the floatline. Further work quantifying height of gillnets during tidal cycles is vital to continued understanding of fine-scale distinctions in habitat use by different species.

Longlines

While not directly relevant to the specific fisheries detailed in the NAFO request, the group felt it worth noting that it is possible to target species with longlines and reduce cod catches by using different baits. This has been demonstrated in a number of studies.

There are studies showing that the catch ratio of cod: haddock is in general lower for longlines than in otter trawls (Engås *et al.,* 1996; Huse *et al*,. 2000, Ford *et al.,* 2008). There are also other studies suggesting that the choice of bait has a significant influence on the bycatch of cod in longline fisheries for haddock (Løkkeborg, 1991).

Experiments completed in Norway using manufactured longline bait based on herring as the feeding stimulant gave catch rates of haddock that were 158% that of natural squid bait, whereas the catch rate of cod for this bait was only 18% that of squid bait (Løkkeborg, 1989). During trials in coastal Massachusetts, Pol *et al.*, (2008) observed that the catch ratios of cod: haddock were lower for Norbait© (0.38) than either herring (1.06) or clams (0.80), these observations are also supported by Ford *et al.* (2008). Unpublished data from trials done with an Icelandic artificial bait in Norway the spring of 2009 show catch ratios cod: haddock at 0.35, 0.30 and 1.3 for artificial bait, sauri and mackerel, respectably. Other unpublished studies from Cape Cod, USA, and Newfoundland, CA also support the reduction of cod:haddock ratio using manufactured herring-based baits.

Pots and Traps

Successful flatfish pots have not been fully developed, although attempts have been made and are reported extensively by ICES, 2008. Cod pots are under development in several nations and show excellent size selectivity but low catch rates make them uneconomic and therefore as yet they have only limited commercial applicability.

Pinkham *et al.*, (2004) reports of a project that explored the feasibility of a seasonal commercial winter flounder trap fishery in Maine's inshore waters. Experimental flounder traps with two different openings were tested. In one design, a standard crab hoop was used. In the other trap design, a smaller (restricted) opening was used in an attempt to exclude a higher proportion of bycatch, particularly legal sized lobsters. A total of 1160 traps were hauled over 33 trips during three different seasons: early summer, early winter, and late spring. The highest catch rates of winter flounder occurred in late spring, although overall catch rates were low, an average of less than 0.5 lb of flounder per trap. The restricted opening design reduced the bycatch of legal sized lobsters compared to the traps with the standard opening during one field season, but results from the second field season were inconclusive. While catch rates in this experiment were not high enough to justify the development of a commercial fishery at this time, results were encouraging and should be used to direct further experimental testing. Future work should focus on setting the traps in areas of higher winter flounder abundance, exploring seasonal timing of a potential fishery, testing alternative bait types, and refining trap opening design.

Discussion

In responding to this request WGFTFB have identified a considerable amount of research work on gear modifications designed to sort cod from flatfish species as well as cod from other species. Gears that size select cod have also been considered. Several gears have been shown to sort cod successfully from flatfish species in the NAFO area 3NO fisheries, while a number of other gear modifications have been shown to reduce cod catches to low levels in other fisheries were cod is a bycatch. In compiling this review, however, it is clear that any gear modification to be adopted must be tailored to the specific fisheries, species composition and gears used in the fishery. It is also evident that all of these gears have limitations and potential disadvantages.

A review of cod and flatfish behavior has revealed that differences between cod and other species do exist, either in terms of natural separation or in its reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations in all of the work reviewed but it is worth noting that from the extensive video observations made by different researchers, cod do not try to display active escape activity and remain calm and quite sedentary once inside trawl nets. This in itself makes releasing them difficult without the added complication of separating them from other species.

From the gears reviewed there are a number of trawl designs such as the Faroese cutaway trawl, Ribas trawl, US Topless trawl, Danish Selective Flatfish trawl as well work with beam trawls in the North Sea that have adopted the same basic design principle of providing cod an escape route in the front section of the trawl. This has been achieved by either removal of the top sheet of the trawl and extension of the headline back behind the ground gear or alternatively by replacing the netting in the top sheet sections with very large mesh or rope panels. The results from these experiments seem quite variable with considerable haul to haul variation but reductions of cod of between 25%–80% have been observed. In most of these trials reductions of have been across all size classes, although in the Danish flatfish trawl, were mainly for cod < 35cm. In some of these trials there has been a consequential reduction in flatfish catches. In the case of the US Ribas and Topless this was 30%–56% for yellowtail and winter flounder above marketable size and between 75%–82% for undersize flounder. Diurnal effects were also noted in these trials, with night tows resulting in the highest reductions in yellowtail flounder catches. Conversely in the other trials, mainly carried out in European fisheries, catches of target flatfish species such as lemon sole, plaice, dab and sole any reductions in catches were found to be negligible, suggesting possible differences in behaviour between flatfish species. Significant losses of other marketable species such as haddock, whiting and monkfish were noted in most trials. In conclusion this type of gear modification does seem to be effective at reducing cod catches but there can be considerable variation due to diurnal conditions and haul effects such as catch size and catch composition. The one advantage of all of these gear modifications are that they are relatively simple and cannot be circumvented easily by fishermen. To incorporate these modifications it is inevitable that in some cases redesign and re-tailoring of the original net design are required. In most cases however, the changes required can be made relatively simply and practically.

Some success has been reported with separator panels to sort cod from flatfish although traditional horizontal separator panels with dual codends developed in the 1980s in Scotland do not seem to work effectively. This gear tends to sort cod and flatfish into the same compartment or codend and so without an additional modification i.e. increased codend mesh size or release panel will not sort cod from flatfish. Trials in Newfoundland reported by Hickey *et al.* (1998) with a horizontal panel resulted in cod being split 50:50 between top and bottom codends. Following these experiments the authors concluded that to prevent high losses of plaice catches the height of the separator panel would have to be set at a level at which 50% of cod catch would be retained, which defeated the objective of this trial, to reduce cod catches to very low levels. Thus it is concluded that the horizontal panel does not seem to be an option if the objective is to sort cod from flatfish although it will sort cod from species such as haddock and whiting very effectively.

Variations of separator panels have also been tested and Danish and Belgian research using an inclined panel has given significant reductions in cod catches. These trials gave reductions in cod catches of over all sizes of 72% and 39% respectively. However, the authors of the reports from these experiments both concede that further work is needed to make these modifications commercially acceptable, given that high losses of commercial flatfish species were also observed in these trials. With the Danish trials the losses of catch, equivalent to 57% of the total catch value were deemed commercially unacceptable. Trials in other fisheries with similar panels, notably in Ireland and Scotland have also shown it possible to divert cod using an inclined panel out through an escape opening with low swimming species such as *nephrops* passing underneath the panel into the codend.

Therefore it is concluded that the use of inclined panels does seem encouraging and may provide a means of reducing cod catch while maintaining catches of marketable flatfish and other groundfish species. However, separator trawls are much more complex than standard nets. The inclusion of the separating panel requires some redesigning of the trawl and the height of the leading edge of the panel above the bottom sheet is critical for species separation (Main and Sangster, 1985). The panel may also need fine-tuning to achieve good consistent separation and the panel also needs to be tailored to each particular trawl design. These are not insurmountable problems but should be noted.

Various designs of rigid grids (Nordmore grids) have been tested in a variety of fisheries specifically to sort cod from flatfish. The results from many of these experiments are encouraging but defining the correct bar spacing, bar orientation (i.e. vertical or horizontal), shape of fish opening, angle of attack and material seems still to be an issue and very much fishery dependent. The trials by Hickey *et al.* (1995) suggested a vertical bar orientation rather than a horizontal bar was more appropriate for sorting cod and flatfish. The best combination they found in their experiments was a bar spacing of 127 mm, set at 67º, which gave a reduction in cod catch of 88%, with corresponding reductions in plaice and yellowtail catches of 9–10%. Similarly He (2002) found a horizontal bar grid worked best for sorting roundfish from flatfish and also included a further modification to the grid with the addition of a large opening on the bottom sheet to release monkfish and skate. Michael and Lee (2009) experimented with a horizontal grid to be bets and in their experiments achieved a reduction in cod catch of 73%, with a loss of flounder of 12%. A slightly different approach has been taken in the Faroe Islands, where the use of the grid is mandatory in one particular inshore flatfish fishery. In this system there is a grid with a 40 mm bar spacing and a two-tier codend arrangement with a codend of 180 mm mesh size placed over the escape opening at the top of the grid to retain big cod and species such as monkfish. The idea of this system is to sort fish and then size select them using different codend mesh sizes. A similar system is now being looked at in the Icelandic shrimp fisheries, where a codend of 135 mm mesh size has been placed over the escape opening to retain marketable cod, haddock and whiting (Einarsson pers. comm.). This is similar to the concept described by Graham and Fryer (2006) with a grid and a two-tier codend, whereby the target species in this case *Nephrops* passed through the grid and was retained in the bottom codend, while bigger fish were sorted into a top codend.

While the results from the trials with grid are not definitive they do show that grids can achieve the objective of sorting cod from flatfish and based on their widespread use in many other fisheries seem to be an option to be considered for the 3NO fishery. In some of the experiments almost the entire cod catch can be excluded form the catch using grids. However, the grids do need to be tailored to meet the requirements of the fishery and the bar spacing and orientation optimized to meet the management objectives and also respect the economic viability of the fishermen. It should also be noted that while grid technology has improved greatly in the last decade, the size and rigidity of grids may still pose problems under commercial conditions for certain classes of vessels. Many trawlers have only narrow net drums, causing stowage problems if the drum is narrower than the grid. Vessels with power blocks may also find it difficult to haul the grid through the power block.

Square mesh and T90 codends as well as large square mesh panels are designed primarily to size select cod. Composite codends are designed to size select flatfish and cod in one codend taking advantage of the differences in behaviour and body shape. These gear modifications are only real useful in fisheries were the intention is to reduce the catch of undersize or small cod. If the management objective is to reduce cod catch across all size classes then these modifications on their own will not meet this objective. By increasing the mesh size of the panels or codends larger fish can be released but at a certain mesh size this will lead to unacceptable losses of other species. An example of this is the recent work in Denmark reported by Madsen *et al.* (2008). With a 150 mm square mesh panel. Cod catches of all sizes were reduced by 36% with a corresponding loss of plaice > mls of only 2%. When the mesh size of the panel was increased to 300–400 mm, cod catches were reduced by 61–85% but plaice catches were also reduced to 70%. In addition to mesh size position of the panel also is important. For cod, research has indicated that the panels should be positioned as close to the codend or as part of the codend to be effective. For other gadoid species such as haddock and whiting position of the square mesh panel seems less important.

It is concluded that square mesh codends and composite codends have been shown to be reasonably effective as size selection devices for cod without reducing catches of flatfish. The composite codends have the added of benefit of being size selective for flatfish species. Large mesh square panels are a simple and cheap alternative and as shown by the experiences with the large mesh Danish windows can be adapted to release cod over a wider size range than simple codends. Further work with these large mesh windows is needed to tailor the mesh size to the fishery and gear to minimize losses of marketable species including flatfish.

Regarding the other gear modifications reviewed by WGFTFB, most of them seem to be effective at reducing cod catches and in the case of the Eliminator trawl and raised footrope trawls can be used to eliminate cod catch entirely across all size classes. However, these gears are only applicable in targeted haddock fisheries as catches of other marketable species are also significantly reduced. The Scottish belly trawls and Orkney trawls are modifications of the Eliminator trawls and have been shown to reduce rather than eliminate cod catches. There is some evidence than they are more effective for smaller cod, although in the case of the Orkney trawls significant reductions in cod catches for fish up to a length of 78 cm was observed. These gears also have the advantage of retaining more groundfish species such as megrim and monkfish so have more potential in mixed fishery situations. It is conclude these gears should be further tested in other fisheries to ascertain whether they are an effective “cod reducing” gear.

As far as the other non-trawl gears examined, at this juncture it would appear there is only limited potential for adoption of these gears as alternative gears. The limited trials with Scottish seine gear are inconclusive although suggest it is technically feasible to sort cod from flatfish in this gear but further work is needed to develop acceptable gear modifications. The work with gillnets is further advanced and through simple modifications reductions in cod bycatch of 50% without significant reductions in flatfish catches have been achieved. Given these gears are perceived as environmentally benign in comparison to towed gears, again further research in this area should be encouraged. Research into using bait as a means of reducing cod bycatch in longline fisheries is encouraging but is only likely to be effective in directed longline fisheries for species such as haddock and possibly halibut. There have been concerted efforts in recent years to develop targeted pot fisheries for cod and flatfish in a number of countries but to date with only limited success, mainly due to low catch rates. This work remains in development phase so could not be recommended as an alternative method currently.

Conclusions

The *ad hoc* group of WGFTFB has produced this compilation of fishing gear and fish behaviour studies which have attempted to separate:

1) Atlantic cod from flatfish including two conducted in NAFO area 3NO and;
2) Atlantic cod from other species including other commercial flatfish species.

Behavioral reviews have revealed that differences between cod and other species do exist, either in terms of natural separation or in its reaction to gear components. These differences and natural separation have been exploited in gear design and fishing operations.

WGFTFB cautions that in the absence of specific details such as gear descriptions, vessel types and management objectives, no single gear modification can be recommended to NAFO at this time. WGFTFB, however, has identified some gear modifications that demonstrate that the separation of cod from other species, including flatfish, is possible. This can be achieved by modifying the front section of the trawl, installing a sorting device such as a rigid grid or separator panel, by using large mesh escape panels positioned above the codend or by modifying the codend itself. These do need, though, to be tailored to the specific requirements of a given fishery and limitations with all of these gears have also been identified and documented. Other modifications such as the "Eliminator" and Raised footrope trawls have been proven to eliminate cod catches almost entirely but are only really suitable for targeted haddock fisheries.

Studies examining separation techniques for non-trawl gears were also identified and briefly reviewed. These include modifications to Scottish seines, gillnets, longlines and pots. Testing of gear modifications to Scottish seine nets is an extension of similar modifications made to trawls. The limited data available is inconclusive but it seems technically feasible to target flatfish with this gear with reduced cod catches.

There has been extensive work with gillnets in recent years and through simple modifications significant reduction in cod catches can be achieved when targeting flatfish species. Gillnets are accepted as selective gears and further research on a commercial basis to establish whether these modifications can yield catches at economically viable levels of other species should be encouraged.

Using bait to sort catches in longline fisheries seems technically feasible but has only really been used to reduce cod catches in targeted haddock longline fisheries. More research is needed to establish whether this can be extended to other fisheries where cod is considered an unwanted bycatch due to stock pressures.

Experiments with fish pots are widespread in many areas and fisheries. Most of this work has concentrated on developing selective fisheries for cod. There are several reports of attempts to develop flatfish pot fisheries but catch rates observed have been at low levels and pot fisheries for fish remain in a developmental phase.

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Annex 9: Eulogy to Professor ALEXANDER L. FRIDMAN, ScD (1926–2007)

Written by Steve Eayrs, Henry Milliken, Menakhem Ben Yami, and Joe DeAlteris,

Presented by Steve Eayrs

Alexander Fridman was a Russian fishing technologist who is most famous in the western world for his book "Calculations for fishing gear design". This book was published in 1986 and remains one the most authoritative, thorough, and important fishing technology books written. Alexander Fridman was a pioneer of fishing technology, including the development of flume tanks and the laws of similarity which permit the use of scale model fishing gears in tests that provide credible performance that mimics the performance of full sized fishing gear. He enjoyed a history of involvement in the fishing industry that extended over 50 years, including roles as a fisheries engineer, fleet manager, scientist and professor at several respected Russian Universities.

Alexander Lvovich Fridman was born in 1926, to a Jewish family in Kherson, Ukraine, a city near the Black Sea. Alexander, like many other Jews in the Soviet Union, had to sustain anti-Semitic obstructions and political suspicion. Alexander tells a story that captures the suspense and uncertainty of the times: "I had an aunt in the United States with whom my mother corresponded. It was 1930 or 1931, and with the arrests of innocent people becoming an ordinary activity, Mamma sent a letter to Lisa, in which she said: "Don't write us anymore. This is very dangerous!" Such concerns followed Alexander though much of his adult life. "As a young adult and since, filling out questionnaires made me wince when the matter concerned relatives living abroad. All the more so, because sailing on board distant waters fishing ships, I had a maritime passport with permission to disembark at foreign ports. In those days I always felt the KGB on my back and that I could be unceremoniously labelled an "enemy of the people" because all my life I had hidden a great secret; My Auntie Lisa, her husband and two children living in the USA".

When Alexander was sixteen, and a bearer of a Golden Diploma exempting him from entrance examinations, he applied to Moscow Aviation Institute (MAI). However before he could get an answer the Germans invaded the USSR. Alexander, his mother, and younger sister escaped by leaving Kherson onboard the last train before the arrival of the Germans, arranged by his father who was an officer in the Red Army. Like many others, he lost many relatives in the war, including relatives who died due to starvation and diseases during the long siege of Leningrad (now St.Petersburg) by the Nazis.

Alexander described their saga: "…without source of living, warm clothes and roof above our heads. However, we were thousand time luckier then relatives and friends who couldn't escape from our city of Kherson." The family settled in Kazakhstan, where Alexander went to a railway school. He spent much of his time in the library, where he became acquainted with the world's classical literature, history, and other general knowledge.

As the war ended, Alexander joined the Moscow Aviation Institute. However, during this time he learned of a whaling expedition to Antarctica and that students from the Moscow Institute for Fishing Technology and Economy might be taken on as crew. Alexander jumped ship, literally speaking, and joined the Fishing Technology institute.

It was here that he was introduced to the discipline of fishing technology by Professor Fyodor I. Baranov. Baranov was a Russian engineer who arguably can be considered the father of fishing technology, or at least, one its founding fathers. Baronov himself lived an interesting, or perhaps more appropriately, tense and uncertain life, and perhaps has not received credit from the western world that he deserves.

Baranov made the first known attempt to calculate the impact of commercial fishing on fishery resources, and was the founder of the optimum catch theory, which in effect is a TAC. Baranov developed the fundamental principles of population dynamics and developed theories to predict future fish stocks based on the catch and effort data from previous years. Many of his theories were revolutionary and an affront to his peers and their thinking at the time. After all, it was only about 40 years earlier that Thomas Huxley made his now-famous quote regarding the inexhaustibility of fishery resources and the futile nature of managing the extraction of fish. Many of Baranov's peers felt that his theories were anti-Marxist and he was accused by colleagues and superiors for trying to introduce reactionary approaches to the Soviet science. Ultimately he was saved from being sent to a Gulag by another famous fisheries engineer, Andreev, who was elected secretary of the Communist Party Committee at the Fisheries Institute.

Baranov founded the first commercial fishery department, which later became the Commercial fishery faculty at the Kalinigrad State Technical University. However, in the 1950's his lectures were banned and he was forced to keep many of his ideas to himself. He suffered over 40 years of hostility and ridicule from his peers, and night after night feared persecution, arrest and transport to the Gulags. Ultimately his theories were picked by the likes of Ricker, Shaefer, Beverton and Holt, who enjoy a reputation based on their contributions to fishery science that still awaits Baranov.

Baranov also pioneered fishing technology by adopting a systems approach to the design and performance of fishing gear; considering fishing gears as "engines", applying to them the laws of hydro-dynamics and mechanics, and thus enabling the analysis and improvement of their performance. Prior to this only descriptive literature existed. Clearly he was a revolutionary thinker well ahead of his time.

It was Alexander's meeting with Baranov and his arrival at the Moscow Institute for Fishing Technology and Economy where he met his calling in life. Young Alexander excelled in his studies, and in 1948 when the time came to complete his degree, wanted to base his thesis on testing model fishing nets. Perhaps it was his earlier experience testing fishing gear components wading in freezing waters that put him on this path, but Alexander began to realize that model fishing nets might offer an alternative (and warmer) testing option. At that time Flume tanks did not exist so he decided to test his models at a large aerodynamic testing installation in Leningrad. One would like to think that it was his time at the Aviation Institute that helped put this notion into his head.

He worked out the mathematics involved and submitted his thesis proposal to his teachers including Baranov. "I was made a laughing-stock; some even called me crazy", wrote Alexander. "It is not easy to catch the idea that the parameters of a fishing gear model in water flow and air flow can be equal under some conditions, so that it would be possible to come from the model test to reliably evaluate the full-scale gear". Ironically, it was his great teacher Baranov, who ultimately dismissed the idea.

Not to let this criticism slow him, and demonstrating a revolutionary streak not unlike that of his mentor, Alexander used his connections at the wind-tunnel and did some testing with positive and encouraging results. He described this, no doubt important technological experiment, as follows: "Usually the wind tunnels had been performing model tests of solid bodies: airplanes, vessels, hydraulic turbines etc. On the day of my tests, most of the staff of the wind tunnel gathered to watch this unusual test – the scaled model of the fishing trawl."

With encouraging results he returned to the Institute, but Baranov was fuming: "Not enough that you haven't listen to your superiors, you had to go and waste the expensive time of our national wind tunnel!"

So - no degree! No Moscow! Alexander was sent packing to work at the Murmansk fishing fleet! Professor Baranov had acted according to the well-proven tradition: hard on your underlings and soft on your superiors.

In 1949 Alexander, recently married to Valentina who remained his wife for over 50 years and herself an accomplished mathematician, arrived in Murmansk. He reported there to a Captain Kireyev, commander of the Murmansk Trawling Fleet, the world's largest. Kireyev was trained in Kherson, Alexander's home city, and he and Alexander found mutual acquaintances and interests. The Captain liked Alexander's ideas towards improved trawl design and appointed him to work at the Murmansk Experimental Base. But Alexander must have been too bright and too successful at the Base. When a wave of anti-Semitism arose in the Soviet Union, Valentina and Alexander were subject to a variety of false accusations and the potential reality of a prison term. Despite his support, Captain Kireyev sent him on board a trawler named "Sevastopol" as a fishing technologist.

Alexander worked for 8 years in the Murmansk fishing fleet, mostly on board trawling vessels, where he was responsible for improving the performance of the fleets fishing gear. The Fridmans then returned to Moscow, where Alexander could enjoy the respect gained in the North and advance professionally.

While in Moscow, he began to set up standardised approaches to modelling of trawls, purse seines, trap nets etc., as well as a procedure for recalculation to the full-scale gear. Starting in 1962, he worked on a radically new approach to gear design on the basis of the theory of models. He employed his criteria of similarity between full-scale gear and its model to compile a system of basic equations for fishing gear calculation and design, and developed the new methodology through multifaceted experimental research studies. Where previously model testing was accomplished to understand the performance of *existing* fishing gears, it was Alexander that took the next step of using model testing to develop entirely *new* gears.

After some time, he moved to the new Fisheries Experimental and Design Bureau in Kaliningrad that later grew to become the Kaliningrad State Technical University (KSTU). Alexander eventually inherited the position of Professor Baranov and served for many years as the KSTU Chair of the Faculty of Commercial Fisheries, where his ideas culminated in the 1980s in the creation of a Computer Assisted System for Fishing Gear Design. His Russian manual in fishing technology caught the eye of the FAO's Fishing Gear Section, and Alexander was invited to the FAO where he worked closely with Ben Yami to produce an English version of his manual. It was published in 1986 by Fishing News Books.

Until his retirement, Professor Fridman and his staff at the KSTU have produced hundreds of fishing gear specialists, mainly from Soviet-block countries, and contributed to KSTU's achieving a leading position in the science and technology of commercial fisheries, not only in the Eastern block, but worldwide. With the falling apart of the USSR, and the following privatization and dispersal of the Soviet fleets, the KSTU started losing both governmental support and consequently its former status.

In 1994, Valentina and Prof. Alexander Fridman arrived at the Australian Maritime College, where a young Aussie fishing technologist had the pleasure of introducing him to Australian life. During their time in Australia Alexander attempted to find ways to remain and perhaps settle down. Unfortunately the AMC was undergoing a major restructure and the inclusion of Alexander was not part of their plans. After some 6 months or so the Fridman's headed to the United States.

My time with the Fridman's was unfortunately too short. I had deep respect for this man, which continues to grow as I learn more of his life, trials and tribulations. I new his work well, both as a student then academic and then manager of a flume tank. It was a privilege to meet him and discuss the future of the fishing industry.

My most treasured memory of our relationship was the day they arrived in Australia and I took them to their accommodation. Not being sure how familiar they were with modern appliances I made sure they new how everything worked, the TV, oven and cook top, how to call me by telephone etc. They understood it all. Breathing a sigh of relief, thinking they will adapt nicely, I introduced them to a microwave oven and tried to explain how it worked. Wide eyes of amazement! This was something they apparently had not seen before and were stunned at what it could achieve. So here I am, with this pioneer and his wife teaching them how to use a microwave! Just goes to show even the wisest of people can learn something new.

The following was written by Henry Milliken and Joe DeAlteris

In 1988 Joe DeAlteris had the opportunity to meet Professor Fridman (Doc as I called him) at the World Symposium on Fishing Gear Technology in St. John's Newfoundland. In their meeting Joe enquired about the possibility of a sabbatical at the Kalinigrad Institute in Russia, and to his surprise, Doc enquired about the possibility of a sabbatical at URI. Some years passed, they corresponded occasionally, but when they met again in the mid-1990s at the World Fisheries Congress in Athens, Doc told Joe that he was planning to come to the US to work at URI, and he would contact him when he arrived! A bit of a surprise to Joe!

Doc and his wife Valentina came to RI to work with Joe DeAlteris around 1995. Joe did his best to accommodate him at URI with an office, the title of Visiting Professor, housing and, as Joe called me, a personal assistant! I had the opportunity to interact extensively with Doc and Valentina. I would go to their house after work to study Russian with Valentina and spent most of the time being fed Russian delicacies (some good some not so good – all heavy on the butter). They adopted me as I think they greatly missed their Son, still in Russia and my presence provided them some comfort. I spent considerable time helping them get started in the USA. My favourite memory was bringing them grocery shopping. When we got to the grocery store (a small one by our standards) they were amazed at the variety and the lack of lines. They asked what they were allowed to buy and I told them whatever they could afford. Their amazement looking at the foods that we take for granted was fantastic. This was one of many fun ventures that I had with them. Some of the other included their first trip to McDonalds, the trips to our local fishing ports and many others. Although I could see their amazement of the USA I also came to understand their love of Russia and the many amazing accomplishments of the Russian people. Doc and Valentina often talked about Kaliningrad, the amazing architecture and the intellect of people working on fisheries issues. It was clear that the Russians, and especially

Doc, were very pragmatic in their approach to fisheries often relying on engineering and calculation when faced with a problem. When I was working on my thesis (large mesh panel in the belly of a trawl to reduce flounder takes) Doc had me consider many aspects that I would normally have not considered. In regards to the large mesh, he helped me calculate the length of fish that was likely able to escape which is a function of the velocity of the water, the burst speed of the fish, secondary hanging ratio of the mesh, the location of the centre of the fish, which determines whether the fish can penetrate the mesh past the centroid of it's body where it will be able to escape. He and I presented this work at an WGFTFB meeting in Woods Hole in 1996 in a paper titled, "Substantiation of the Use of a Trawl Escape Panel and Determination of its Operational Parameters".

Throughout the later part of the 1990s Doc contributed to the faculty, staff and students at URI. He worked on several projects with students, and, like he did with me, was always challenging them to think far beyond their normal bounds. Alexander was concerned about the direction that fisheries was proceeding both in the US and worldwide, so after several years of writing, in 1998 Alexander published his final technical work, "World Fisheries, What is to be Done". For him this was the culmination of his experience, the engineer and technologist addressing management issues.

Sadly the love of his life, Valentina had health problems in the first couple of years in the new century, and he devoted his time and effort to caring for her. In fact, the local newspaper carried a story about their life-long love affair and his caring for her. Ultimately she passed away, and Alexander slipped into a period of depression, but when he emerged from that, he became a philosopher and a poet. He spent his last years writing poetry, and sharing stories about his youth and his professional life in Russia. Doc won several awards for his poetry, and was proud of this new facet of his life. During the last couple of years of his life he managed to convince the creditors in the USA that he could afford a waterfront home, new cars etc. They were all eventually taken from him, but Doc enjoyed a prosperity that showed that even late in life, he had what it takes. Ultimately Doc became ill and died in 2007.

The professional legacy of Alexander Fridman is the great works that he published on fishing gear technology, that remain as relevant today as they were when they were written more that 40 years ago. His students and colleagues will miss his brilliance and wit. I will also cherish the memories of the friendship of Doc and his wife Valentina.

Dosvedanya!