ICES WGFTFB REPORT 2014

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

5–9 May 2014

New Bedford, USA

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Executive summary

The ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB) met in New Bedford, Massachusetts, USA from the 6 to 9 May 2014 to address four Terms of Reference. The main outcomes related to the ToRs are as follows. Details of the topic group presentations and findings can be found in the respective sections.

Key Findings

Dynamic catch control devices (Section 8)

- The group reviewed techniques for controlling the catch in Danish seine fisheries for cod and haddock. The group discussed implications of cod escaping from the seine net during the haulback operations that are often associated with decompression and its impact on fish survival.

- The group reviewed techniques tested in Norwegian purse-seine fisheries for catch controls of mackerel and herring, including: 1) acoustic instrumentation for improved pre-catch identification of fish schools in terms of species, quantity and fish size, 2) methods and equipment to estimate the catch volume, fish size and quality at an early stage of pursing while slipping is still acceptable, 3) seine net designs and techniques that minimize mortality associated with slipping.

- The group identified technology gaps and weaknesses including challenges in identifying codend catch volume, image/video wireless transmission; automated codend closing device reliability, high cost of devices, and catch sampling of purse-seines.

- Future applications of artificial light in fishing gear design and operations (Section 9)

- The group described and summarized fish response to artificial light stimuli.

- The group described and summarized the use of artificial light in world fisheries.

- The group described and tabulated different light sources to attract fish.

- The group summarized challenges of current use of artificial lights in fisheries and identified/suggested potential solutions.

- The group Identified new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.

- The group will provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.

Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries (Section 10)

- The results from the topic group are used in BENTHIS framework for assessing fishing pressure

- The results from the topic group are used in MyGears framework for assessing Technical specifications of Mediterranean trawl gears

Technical Innovation in Spreading Trawls (Section 11)

A suite of new fishing innovative technologies for spreading trawls that reduce seabed impact and reduce fuel consumption was presented. Some examples discussed in the topic group include:

- The Dutch SumWing for North Sea beam trawls,
- The French "Jumper door" with less bottom impact,
- The semi-demersal trawl for cod in the Barents Sea,
- Innovative light-weight trawl doors in prawn fisheries in North Australia,
- Redesign of trawls with raised doors and Dyneema warps and netting in demersal trawling in Denmark,
- Dynex warps and controllable pelagic doors in Iceland,
- New designs of beam trawls in the Newfoundland shrimp fishery,
- A new Wing Trawling system for the shrimp trawls in the US,
- Semi-circular plates spreading groundgear in Norway, and
- The Gloria self-spreading pelagic trawl in Iceland.

Directive

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

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

1   Introduction

Chair (ICES):   Pingguo He
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Venue: New Bedford, USA

Date: May 6–9, 2014

2   Terms of Reference

The **ICES-FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chairs: Pingguo He, USA; Petri Suuronen, FAO) met from 6 – 9 May 2014 in New Bedford, USA.

Terms of Reference (ToRs)

a. **Innovative dynamic catch control devices in fishing.** A WGFTFB topic group of experts will be formed in 2013 to investigate innovative dynamic catch control devices in fishing. Dynamic catch control systems are defined as catch control systems that change the structure and functioning of the gear during the fishing operation so that the gear stops collecting fish when desired amount of fish has entered the retention part of the gear, or actively releases excessive fish with least level of mortality. To be convened by Eduardo Grimaldo (Norway) and Mike Pol and Pingguo He (USA). The group will have the following terms of reference:

  i.   Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.
  ii.   Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears worldwide.
  iii. Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

  a) *Convener: Eduardo Grimaldo (Norway), Mike Pol (USA) and Pingguo He (USA).*

b. **Future applications of artificial light in fishing gear design and operations.** A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions. Specifically the group aims to:
  i.   Describe and summarize fish response to artificial light stimuli;
  ii.   Describe and summarize use of artificial light in world fisheries;
  iii. Describe and tabulate different light sources to attract fish;
  iv.   Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions;
  v.   Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods.

Convener: Heui-chun An (Korea) and Anne Chris-tine Utne Palm (Norway).

c. **Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries.** A WGFTFB topic group of experts will be formed to investigate relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries. The group will have the following terms of reference:

    i.   To review technical specifications of trawl gears used in different fisheries (benthic, demersal and pelagic) with attention, in particular, to the dimensions of headline, footrope, circumference or perimeter at various levels of the net, extension piece, codend, otterboard, and other aspects;

    ii.   To model and describe relations between engine power and gear-size characteristics of European trawl fleets. Modelling engine power and different parts of the fishing gears as well as between some of these parts and the otter-board size should be investigated.

Convener: Antonello Sala (Italy).

d. **Technical Innovation in Spreading Trawls.** A WGFTFB topic group of experts will be formed in 2014 at the meeting in New Bedford, MA, USA to document and evaluate recent technological advancements in spreading technology for mobile trawls. The group will have the following terms of reference:

    i.   Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.

    ii.   Review technical challenges and obstacles for uptake by industry.

    iii.   Identify new applications for these technologies and opportunities for technology transfer.

Conveners: Paul Winger (Canada), Bob van Marlen (Netherlands) and Antonello Sala (Italy)

3   Participants and agenda

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

4   Explanatory note on meeting and report structure

The first day of the meeting was devoted to an open session structured as a symposium where talks were presented on a range of topics of interest to WGFTFB. The second day of the meeting was devoted to a special topic on 'selective fishing and balanced fishing'. The third included some talks relevant to the topic groups followed by meetings of the topic groups. On the fourth and final day, the topic group conveners reported on their deliberations and other procedural matters were dealt with.

In general, the conveners of the working groups prepared reports of their work by correspondence throughout the year and at the meeting. 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 the more detailed reports do not necessarily reflect the opinion of the WGFTFB. Some topic groups included small numbers of individual presentations based on specific research programmes related to that topic. The abstracts are included in this report and were NOT discussed fully by the group, and as such, they **do not necessarily reflect the views of the WGFTFB**.

5   FTFB Open session

5.1   Oral presentations

5.1.1   Survival experiments in the Netherlands in 2012 and 2013

Bob van Marlen and Kees Goudswaard
IMARES, PO Box 68, IJmuiden, 1970 AB, Netherlands

IMARES did a short study on the effect on storing hatched sole in fish survival tanks (0.6x0.4x0.12m) both in the lab (control groups) as on FRV "Tridens" in December 2012. Groups of 50–55 individuals were used, with five fish per tank. No single fish died in all three groups. A survival experiment with hatched sole (< MLS; as control group) and undersized sole from catches (test group) was carried out in April and May 2013 from a commercial 2000 HP pulse trawler (TX-43). Six underwater cages were filled in April with 15 sole (hatched, control) and 15 sole (caught, test group) each, placed on the bottom at 30 m depth and survival monitored for 48 h. The seawater temperature was low at ~ 7°C. In addition, undersized sole and plaice from the catch were stored in two large on-board tubs and survival monitored for 36–71 h. The survival of fish in the cages was low: 1.2% for the control fish and 14.4% for the test fish. The tub trials showed better survival some 60% for sole after 36 h, and 90% for plaice after 40 h, dropping to 80% after 71 h. The survival in test and control groups was low when using the cages, and the cause of death questionable (temperature shift, polluted water). In the second experiment six cages with filled with 15 undersized sole caught from the fish processing conveyor belt and 15 from the deck hoppers, and 2 stacks of 9 on-board tanks each with three undersized sole caught from the conveyor belt and from the deck hoppers. Seawater temperature was ~ 11°C. The observation time was 72 h. The survival rates were as follows: in the cages from the belt 61%, from the hoppers 63%; in the on-board tanks from the belt 70%, from the hoppers 56%. There was not enough

data for statistical analysis of covariates. A second series of trials took place on a smaller 300 HP vessel (TH-10) in July 2013. In the first experiment there were 17 cages filled with in total 324 undersized plaice, 150 sole, 16 turbot, 14 brill, 10 flounder, 3 dab and 1 lemon sole from the catches, and two large on-board storage tubs. The air temperature was relatively high at 22°C, and seawater temperature was 17–18°C, the cages were set at a depth of 20–30 m. The highest survival was found for sole (27%, after 154 h) followed by plaice (11%, after 145 h). Survival was low for turbot, flounder and brill, while for the other species the numbers were very low for analysis. In the second trial the 17 cages were filled with 275 undersized sole and 199 plaice, in most cases 30 fish per cage. Now the survival was extremely low: 5% for sole after 204 h and 0% for plaice after 157 h. All fish were taken from the conveyor belt. The circumstances differed greatly from the ones on the first vessel. This boat had less deck space, fewer people in the fish processing line, and there were higher air and seawater temperatures. The cage survival was low, which may have been caused by sand in codends, the higher temperatures. Often there were large numbers of starfish present in the cages, which may have eating fish remains. A comparison of survival for plaice and sole was made from several references with observation time of 72 h, and for TH-10 ~165 h. Both the conventional trawls in van Marlen *et al.*, 2005 and Revill *et al.*, 2013 gave a mean survival rate of 40% of the observed plaice, and sole. The data from van Beek *et al.*, 1990 showed lower values at 20%, and 15%. The mean values for the pulse trawls were higher 70% and 50%. The TH-10 data were lowest, but in these experiments the observation time was much longer. These are preliminary findings, and need to be re-investigated with further experiments.

5.1.2 Can we reduce unobserved crab mortality from bottom trawling in the Bering Sea? Accomplishments with cooperative research and trawl gear modifications.

Carwyn Hammond*, Craig S. Rose and John R. Gauvin
NOAA/NMFS/Alaska Fisheries Science Center, Seattle, WA, USA
* Presenting author

The mortality of crabs encountering bottom trawls has long influenced management of both Bering Sea groundfish and crab fisheries. Using research funding from the North Pacific Research Board we were able to provide estimates of mortality rates for crabs that encounter, but escape, trawls. We demonstrate how this unobserved mortality could be reduced by doing three simple things: 1) Increasing the diameter of the footrope roller gear; 2) Increasing the distance between individual rollers on the footrope 3) Slightly raising the trawl sweeps off the seabed. These raised sweeps were developed to reduce effects on structure-forming seabed organisms. During these NPRB projects, we worked cooperatively with the Bering Sea flatfish industry to ensure practicality and relevance to their commercial fishery. We estimated escape mortality for crab and escape rates for commercial fish species using auxiliary nets fished behind the sweeps and the footrope and a validated Reflex Action Mortality Predictor (RAMP) for *Chionoecetes* spp. The tested gear modifications reduced unobserved crab mortality by approximately three-quarters. The raised sweep modification was put into regulation in 2011 by the North Pacific Fishery Management Council with full support of the flatfish industry. Bering Seabed trawl fisherman have voluntarily adopted footropes with larger bobbins and wider spacing and our research showed that this configuration reduced unobserved mortality of crabs. This research could not have been done without working cooperatively with Bering Sea flatfish industry, gear manufacturers and demonstrates the value of cooperative research.

5.1.3 The effect of lifting panel on grid-based selectivity

Eduardo Grimaldo, Manu Sistiaga, Bent Herrmann and Roger Larsen
SINTEF Fisheries and Aquaculture, Brattørkaia 17B, Trondheim, Norway

A sorting grid section with a combination of a grid, a lifting panel and guiding panel potentially reduce the water flow, and can provoke that fish start to accumulate in front of the grid. Small-scale tests measured the reduction in water flow, and fishing trials under commercial showed that the lifting panel had in fact a significant effect on the parameter "grid contact" (Cgrid; the probability that a fish comes into contact with grid), thus on the selectivity of cod. The presence of the lifting panel increased the contact probability by 16%, and when compared with a grid section without lifting panel (Cgrid = 0.66) there was an improvement of 24%. At catch rates of approx. 20 tons per tow hour, the 24% improvement in grid contact represent many thousand small cod been sorted out of the trawl**.**

5.1.4 Hake selectivity trials with Argentine trawl fishing industry.

Julio García* and Ricardo Roth
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* Presenting author

Common hake (*Merluccius hubbsi*) is considered a very important component of the Argentinean fishing industry in the Southwest Atlantic Ocean. In order to contribute with the escapement of hake juveniles, several sorting devices were tested by INIDEP. Hard and soft grids, like DEJUPA and Flexigrid, gave selectivity parameters according to the advisable length at first capture L50=35 cm. In 2010 the Federal Fisheries Council states that it is desirable to have the consensus of the industry and continue the search for new options of selective systems as alternatives of the DEJUPA and viable, according to INIDEP. This presentation details the experiences of selective fishing devices submitted by the Argentine fishing industry and that were evaluated by the INIDEP Fishing Gear Group on commercial vessels. Estimations of the retention curves and selectivity parameters for each device are presented.

5.1.5 Temperature effect on heart rate and white muscle activity during swimming exercise of jack mackerel, *Trachurus japonicus*

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* Presenting author

The physiological condition of jack mackerel 16.5 – 21.2 cm in fork length (FL, n = 24) was monitored using electrocardiography (ECG) and electromyography (EMG) technique during swimming exercise in the flume tank and during recovery phase in relation to exhaustion level at different temperature of 10, 15 and 22°C. EMG monitoring demonstrated that the activity of white muscle at the lowest temperature (10°C) was firstly occurred at the swimming speed of 3.2–3.5 FL/s, slower than those at 15 and 22°C as 4.0 – 5.4 FL/s, for determining the sustained and prolonged speed level. The heart rate of jack mackerel was significantly increased by swimming speed increase for each individual in each temperature of 10, 15 and 22°C. The result of EMG and ECG monitoring indicated that the threshold level for prolonged speed was around 3.2 FL/s at 10°C, 4.0 FL/s at 15 and 22°C. The highest swimming speed achieved in 22oC was

5.9 FL/s, where the high heart rate was observed as 150–200 beats/min. The recovery time monitored by ECG as the time required from the peak heart rate to the control level was 3.0 – 8.0 hours after terminating the swimming at prolonged speed.

5.1.6   Recent Scottish trials on the physical impact of trawl gears

Finbarr G. O'Neill* and Keith Summerbell
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* Presenting author

We present the results of recent trials carried out in Scotland to investigate the physical impact of trawl gears on the seabed. The hydrodynamic forces, the associated re-suspension of sediment and the geotechnical forces acting on different cylindrical components (groundgear disks, clump weights, etc.) are explored. Particular reference is given to the effect of size, weight, aspect ratio, towing speed, and whether a component is rolling or not. We show that the while the weight of a component does not influence the amount of sediment re-suspended, the towing speed does. Also on the sediment tested, as the speed increases the drag due to contact with the seabed decreases (presumably as the component penetrates less into the substrate).

5.1.7   The evolution of the New Bedford style scallop dredge

Ronald Joel Smolowitz*, Farrell Davis, Christopher Parkins
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* Presenting author

The Atlantic sea scallop is the most important Molluscan shellfish species commercially harvested in the United States. In 2012, USA landings of sea scallop meats totaled 25,992 metric tons with a value of $559 million. Harvesting problems in the wild capture scallop fishery have a long history of being addressed with technical gear-related solutions. Recent advances include larger rings and twine tops, turtle chain mats, and changes to the drag frame and bag design to reduce the bycatch of sea turtles and flatfish. Management strategies and gear design must work together for sustainable fisheries.

5.1.8   Addition of light to an experimental footrope caused increased escapement of one flatfish species

Craig S. Rose and Carwyn F. Hammond.
NOAA/NMFS/Alaska Fisheries Science Center, Seattle, WA, USA

Trawl modifications to reduce damage to seabed animals also need to maintain catch rates of target species. The FishSkimmer, an experimental trawl footrope component, was designed to reduce damage by being movable upon contact with stationary objects, while still maintaining visual and tactile stimuli for fish capture. To test if visual stimuli were usefully increased by adding an LED light (http://www.lindgren-pitman.com/c-4-electralume-battery-powered-fishing-lights.aspx) to each FishSkimmer device, tows of a trawl equipped with auxiliary nets to capture fish passing under the footrope were made with and without lights installed. Addition of lights had no significant effect on escape rates of one species of flatfish (flathead sole, *Hippoglossoides elassodon*) and a roundfish (Alaska pollock, *Gadus chalcograma*). However, they had a dramatic effect in a direction opposite to expectations (approx. 3X more escapes) for another flatfish species (southern rock sole, *Lepidopsetta bilinetata*).

5.1.9 Effects of a new magnetic device on the fuel consumption of fishing vessels

Emilio Notti*, Antonello Sala
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*Presenting author

An innovative magnetic device for the reduction of fuel consumption and pollutant emissions has been installed onboard an Italian trawler since April 2013. Through this device, a magnetic treatment is applied to the incoming fuel in order to increase the air/fuel mixing process. The consequence of treating fuel with a high magnetic field is supposed to improve combustion of fuel and consequently increasing engine power as well as reducing fuel consumption. The test has been carried out on board a fishing vessel where a fuel consumption measurement system conceived at CNR-ISMAR of Ancona has been installed in 2008 and it is still collecting energy use. Energy saving has been assessed by comparing the actual fuel consumption with that measured before the magnetic device installation. The monitoring plan included also emissions measurements in order to evaluate the effects of the magnetic device on the pollutant emissions. Emissions measurements during different operating conditions were carried out and results were compared with other trawlers with similar vessel, engine and gear characteristics. Preliminary evaluation on fuel usage demonstrated a fuel consumption reduction of about 6%.

5.1.10 Computer simulation and flume tank testing of scale engineering models: How well do these techniques predict full-scale at-sea performance of bottom trawls?

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*Presenting author

A Canadian demersal survey trawl (Campelen 1800) was used to investigate the differences in trawl geometry and resistance using dynamic simulation, flume tank testing, and full-scale at-sea observations. A dynamic simulation of the trawl was evaluated using DynamiT software. A 1:10 scale model was built and tested in a flume tank at the Fisheries and Marine Institute of Memorial University of Newfoundland (Canada). Full-scale observations of the Campelen 1800 in action were collected during the 2011 fall multispecies survey aboard the research vessel CCGS Teleost. The numerical and physical modelling data were assessed to determine their ability to predict full-scale at sea performance of the Campelen 1800 trawl. The numerical simulation data were also compared against scale model engineering performance under identical conditions. The study demonstrates that the ideal method with which to accurately predict full-scale at-sea performance of bottom trawls or used for designing a trawling system probably does not exist. Therefore, the importance of using two or three complementary tools should be encouraged as an ideal process for designing a trawling system and/or assisting the gear development circle.

5.1.11 Simulating the physical behaviour of seine ropes for evaluating fish herding properties of Danish seines

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The Danish Seine is an active bottom fishing gear, which consists of seine ropes and a net. The seine ropes and net is laid out on the fishing ground with the seine ropes encircling an aggregation of fish on the seabed. The encircled area by the seine ropes is typical much bigger than the swept-area that will be covered by the seine net during the fishing process. Therefore, the catching efficiency of a Danish seine depends on the ability of the seine ropes to herd the fish into the path of the net, and subsequently keep them there until overtaken by the net at the later stages of the fishing process. Knowledge of, how the size and shape of the encircled area is gradually changed by the seine ropes during the fishing process is necessary. Combining this information with operational-, gear rigging- and gear design- parameters is therefore important for obtaining an efficient fishery. Here, we report on a Norwegian research project that aims at simulating Danish Seine fishing. A key element in this project is to be able to simulate the behaviour of the seine ropes on the seabed during the different stages of a Danish seine fishing process. For a set of different operational and design cases we present simulations of the Danish seine ropes behaviour during the fishing process and discuss how, and to which extent, this may affect the catch performance of the Danish seine.

5.1.12 Excess Fish Exclusion Device (ExFED): How to passively release fish at depth during trawling.

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Historically high populations of Atlantic cod in the Barents Sea are currently leading to excessively large trawl catches. This leads to reduced quality when the catch exceeds vessels' production capacity, increased risk of discarding, gear damage and safety concerns. Therefore, at the request of the industry and managers, a passive system was developed to limit maximum catch size. The Excess Fish Exclusion Device (ExFED) consists of a fish lock just behind a rectangular hole in the upper trawl panel covered by a mat attached only at its leading edge. The fish lock prevents the targeted quantity of fish from escaping during haul back. Initially, the mat lays against the top panel of the trawl sealing the hole. As fish accumulate and fill up to the fish lock, water flow is diverted out the hole, lifting the mat and allowing excess fish to escape at the fishing depth. The system is mounted at a distance from the cod line to achieve the target size catch for the vessel. Six Norwegian vessels were given approval by the authorities to use the system during commercial fishing in 2013. The system design was improved based upon feedback between from the commercial fleet and gear researchers. Based upon their success to date, industry, managers, and researchers have agreed to further develop and test the system in additional trawl designs on additional commercial vessels during commercial fishing in 2014.

5.1.13 Catch limitation in demersal seines.

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Norwegian fishers using demersal seine gear sometimes catch quantities of cod and haddock that exceed their vessels' capacity to handle, both in relation to safety and the ability to maintain catch quality. The Fish Capture Research Group at the Institute of Marine Research is currently working on a solution for limiting catches to a manageable size while ensuring that excess fish are released at depth in order to minimize mortality of escaping fish. Four gear modifications were tested during trials on board a commercial vessel in March 2014 and escaping fish were observed on video. The preferred solution is a set of two 175 cm long slots cut longitudinally in the trawl just ahead of the codend. The slots remain mostly closed when catch rates are low, but open as the extension fills with fish. A "fish lock" retains fish already inside the codend, preventing them from swimming forward and escaping through the slots during haulback. The target catch quantity can be adjusted by choking off the codend at varying position behind the fish lock. The commercial fleet has been given dispensation to use this gear modification for the remainder of the 2014 calendar year. A video summarizing the project and results is available at: http://youtu.be/p8MYDRSEtyE

5.1.14 GEARNET: Summary and successes of a new approach to conservation engineering.

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GEARNET is a multiyear, multi-institution collaborative research network that worked closely with groundfish fishers to identify, and fund priority projects to pilot innovative fishing gears, and methods that reduce bycatch, avoid waste, or improve efficiency. Using a bottom–up approach, over 35 different projects with >125 industry participants were developed and funded over the 3.5 years, focusing on 6 different themes: fuel saving; trawl selectivity; gillnet selectivity; alternate gears; seabed impact; education. Despite the close working relationships developed with fishers, success of the project was mixed. We present a summary of this project and explore whether this initiative achieved goals of being more efficient, more effective, and with greater uptake of new fishing technology than previous collaborative research models.

5.1.15 A framework for change in commercial fisheries: Can a new approach provide additional benefit to fishers and others?

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*Presenting author

With little difficulty, it is possible to unearth examples of seemingly inexplicable behaviour by fishers in response to change in their fishery, be it a mandated management requirement, an opportunity to protect the very habitat they depend upon, or an opportunity to enhance profitability and viability. Underpinning such behaviour by fishers is a fierce streak of independence and a culture that views change with suspicion, uncertainty, and even scepticism. Change can also be considered a threat to established processes and systems that forces fishers to face an unknown future, and their acquiescence is often achieved unenthusiastically, even if the benefits of change are clear. Worldwide, models of change management have been applied by many corporations and institutions to successfully introduce wide-ranging change initiatives and introduce a culture that embraces change. However, while similar initiatives in fisheries have sometimes mirrored fragments of these models, the deliberate application of entire models appears scant. We present a model of change that has received widespread critical acclaim that has the potential to efficiently guide the successful introduction of change initiatives in the fishing industry. We demonstrate how this model can be used a priori to prepare for the challenges of working with the fishing industry, and using examples from recent research in New England, demonstrate how it can be used retrospectively to identify why past change initiatives were successful or otherwise

6 FTFB special session on 'Selective fishing and balanced fishing'

6.1 Oral presentations

6.1.1 Selective fishing, non-selective fishing and balanced fishing: Concept, consequences and challenges.

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Selective fishing might have practiced since fishing began as most fishing gears inherently select for species and size. Fuelled by a desire to reduce bycatch and discards that are viewed as a waste of fisheries resource, the fishing industry are required to use the most selective gear that targets only certain species and sizes to meet the requirement of minimum sizes and individual species quota. However, these fishing practices may contradict the concept of ecosystem-based fisheries management strategy that aims for maintaining marine ecosystem structure and functioning. It has been suggested that fishing spread over more groups and sizes may result in higher long-term yields (balanced fishing). We compared the trade-offs between selective, non-selective and balanced fishing practices by considering specific circumstances, applications, and technological challenges. Our analysis suggests that balanced fishing may be realizable where all the species were caught in dedicated single species fisheries. However, to be successful in any scenario where a relatively large number of species were caught together, balanced fishing would require such a degree of management of the species and sizes caught that it would be difficult if not impossible to achieve. Hence, balanced fishing would actually require considerable improvements in selective fishing, both in terms of species and of fish size. We conclude that where fishing effort and landings is less easily controlled and monitored, mandating the use of more selective gear may provide a simple mechanism for reducing overexploitation. Balanced fishing is still an ambiguous concept that requires elaboration, development and testing, and it may not be practical in many fisheries.

6.1.2 Mean trophic level analysis as indicator for balanced harvesting – Case study on Japanese-type set-net, in Thailand.

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Japanese type set-net was introduced to Rayong Province, Thailand, in 2003, and successfully operated by the fisher's group with full records of catch and market data for 11 years. For aiming the assessment of fishing impact and sustainability of Rayong set-net, the up/down trend of mean trophic level for catch composition was first examined

on 2010, by means of FAO FISHBASE datasheet to identify the trophic level of major catch species. The mean trophic level of set-net catch was assessed as 3.5, to show the stable trend for 6 years in 2003–2009, without any particular indication of fishing down or fishing up as the stationary passive gear. For confirming this trend as the index to analyse the fishing impact, the trophic level of catch species were examined through the carbon and nitrogen stable isotope analysis compared with muscle tissues and stomach contents, for the samples from set-net and other coastal gear on 2012–2013.

6.1.3   The potential of fisheries selectivity to promote sustainability.

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An age structured population model parameterized for a wide range of stocks is used to study the effects of selectivity on SSB and yield. For this, a generic selectivity metric, namely the difference between mean age-at-capture and mean age-at-maturity, is introduced. The effect of selectivity on SSB and yield is compared to the respective effects of exploitation rate and biological parameters, using Generalized Additive Models (GAMs). We show that yield is mainly driven by biological parameters, while SSB is mostly shaped by the exploitation regime. Selectivity is more influential than exploitation rate for both yield and SSB. Catching fish, a year or more after they mature combined with an intermediate exploitation rate (F ≈ 0.3 y 1) promotes high sustainable yields at low levels of stock depletion. Empirical exploitation regimes of 31 ICES stocks are compared to the optimal regimes identified by the simulation analysis, illustrating the unfulfilled potential of most empirical stocks for higher sustainable yields due to high juvenile selection.

6.1.4   Alternative strategy for size selectivity of trawls.

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Recent research in fish biology has demonstrated that older individuals of several fish species including cod can have better reproductive efficiency than younger mature fish – and are therefore important for the relevant stocks. These findings are not supported by the current strategy used to improve trawl selectivity, which aims at releasing small sized individuals and retaining larger ones, resulting in selection curves where the retention likelihood increases with fish size. However, when combining existing technologies for selection devices, it would be possible to develop gears with adopted size specific retention likelihood, which also take into account the reproductive importance of large fish. Here, we present the results from a recent sea trial, carried out in Baltic Sea, demonstrating that it is possible to achieve a so-called 'bell-shaped' selectivity curves by means of technological modifications in the standard trawl, used in the Baltic cod-directed fishery.

6.1.5 Understanding and predicting the size selectivity of red mullet (*Mullus barbatus*) in Mediterranean bottom trawl codends with different mesh configurations.

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Red mullet (*Mullus barbatus*) is one the most important commercial species for the Mediterranean bottom trawl fishery. For this reason, several experimental studies have been carried to assess the codend size selectivity for red mullet in bottom trawls during the last decades. This has included testing different mesh sizes and mesh configurations in codends. Recently, the experimental red mullet selectivity studies have also included investigating the effect of turning the codend diamond mesh netting by 90 degrees (T90) compared to the traditional use (T0). However while the amount of experimental-based studies are considerable on the size selection of red mullet very little theoretical work exists which try to understand and explain the experimental obtained results for this species. Especially no theoretical work exists which are able to explain and thereby enable further predictions on the size selection of red mullet in codends with different mesh configurations including explaining the difference for T0 and T90 codends. The main objective of this study was to establishment a theoretical-based framework for explaining and predicting size selection of red mullet in codends for bottom trawls with different mesh configuration with the focus on T0 and T90 codends. The study was based on for the first time applying the FISHSELECT methodology on a Mediterranean fishery species. FISHSELECT is based on a combination of laboratory experiments and computer simulations that involves assessment of the fish morphology relevant to size selection. We demonstrate how results for size selection of red mullet obtained from experimental fishing can be understood based on morphological characteristics of the species and codend mesh geometry. This further enables us to make predictions for size selection of red mullet for mesh configurations that has not been tested experimentally.

6.1.6 Understanding and predicting size selection of cod (*Gadus morhua*) in square-mesh codends for Danish Seining: a simulation-based approach

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Danish Seining is an important active fishing method to harvest cod (*Gadus morhua*) in Norwegian fisheries. Knowledge of size selectivity of cod in this type of active fishing gear is therefore of importance for managing the exploitation of the cod resources. However, very limited data exists on the size selection of cod in the square mesh codends applied in this fishery. By using the fish morphology and computer-based simulation method FISHSELECT, we investigated the size selection of cod in square mesh codends for Danish seining. We were able to explain and understand existing experimental selectivity results and further based on this, to predict the effect of design changes and operational practices on the size selection of cod in codends for this fishing method. The results showed that the currently applied codend designs should warrant low catches of cod below the minimum size for this fishery. It also indicated that a considerable part of the size selection may occur through slack meshes and therefore likely when the codend is at the surface during the final stage of the fishing process. This may have negative influence on the survival rate of escapists.

6.1.7   Trouser trawl selectivity trials to help re-establish an Acadian redfish *Sebastes fasciatus* fishery in the Gulf of Maine

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REDNET is a multi-institutional collaborative research network tasked with re-establishing a sustainable trawl fishery for Acadian redfish *Sebastes fasciatus*. This initiative was driven by the rebuilding of a decimated redfish stock and its subsequent under-harvest. So far, in this multiyear, multi-phase project, we have demonstrated that redfish can be targeted using mesh sizes smaller than permitted by time and area and that local demand for redfish product can be augmented. In the latest phase, fifty-six tows were completed in March and April 2013 using a commercial fishing vessel and a trouser trawl, testing three diamond mesh codends (114 mm, 140 mm, 165 mm) against a 63 mm codend as the non-selective control codend. Based on the results for individual tows, a predictive model for the effect of codend mesh size on mean L50 and mean SR was established. From this model, mean L50 and SR, and confidence intervals were estimated for all three tested codends, incorporating both within and between haul variability by using the selectivity software SELNET. All measures of model validity were positive. Simulation of fishing with the three tested codends on the observed population indicated that substantial escape of redfish through codend meshes occurs (48–94%), suggesting that investigation of escape of redfish is warranted to support a sustainable fishery. These results are intended to guide the managers and fishers on size retention of redfish and appropriate codend mesh size for the revitalized fishery.

7   FTFB topic group session

7.1.1   Oral presentations

7.1.2   Application of low-power underwater light to a large-scale trapnet fishery. Sonar observation and tagging experiment

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The fish attraction system consisting of a 55-W underwater discharge lamp and a surface buoy that contains batteries was tested for the purpose of improving the catch efficiency of the large-scale fish-trap and reported in the FAO-ICES mini-symposium at Bangkok. This is a follow-up study to investigate fish behaviour. We observed fish behaviour around the trapnet by using a scanning sonar. Fish schools were frequently observed around the lamp during illumination and they moved to the entrance of the trapnet when the lamp was turned off. We also released tagged jack mackerels before, during and after illumination from three locations. Recapture rate of jack mackerel released during illumination was higher than other time periods. Underwater illumination helps fish staying around the trapnet and consequently improve capture performance of the trapnet gear.

7.1.3   Semi-pelagic doors in the New England groundfish fishery

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With increasing concern over the impact of rising fuel prices on profitability, fishers in the New England groundfish fishery have begun to show interest in the use of semi-pelagic otter boards. Research by the Gulf of Maine Research Institute has demonstrated the use of these doors reduces fuel consumption by approximately 12% compared to bottom tending otter boards, with little or no loss of commercial catch. They also reduced seabed contact by 95%. To encourage their uptake, a unique financing model was developed whereby repayments were capped at 10% so that fishers could simply redirect money saved for fuel to their repayments. A subsidy was also provided to cover the cost of fuel meter installation. Unfortunately, many fishers balked at adopting these otter boards due to substantial reductions in the quota of cod and flounder, and so interest in this model was modest. A new initiative has been developed whereby fishers can trial these otter boards for no cost for a short period. In this way it is hoped to substantially increased interest in these doors, reduce fuel consumption, and remain profitable at this very difficult time.

7.1.4 Research into catch control in purse-seine fisheries in Norway

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The release or "slipping" of schooling species like mackerel (*Scomber scombrus*) and herring (*Clupea harengus*) in the later phases of hauling during purse-seine fishing has been shown to induce high mortality among the released fish. Unsuitable catches, with respect to species, fish size and/or quality, or excessively large catches are the main reasons for slipping in these fisheries. In 2011, Norway introduced regulations banning the deliberate release of fish in the later stages of the purse-seine haul in an attempt to minimize the unaccounted or collateral mortality from these fisheries. A research program has been launched in Norway that aims to provide fishers with tools that will minimize the need for slipping and, where slipping is unavoidable, maximize the survival of "slipped" fish. The program focuses on three main areas of development: 1) acoustic instrumentation for improved pre-catch identification of fish schools (in terms of species, quantity and fish size) to prevent catching unwanted fish; 2) methods and equipment to estimate the catch volume, fish size and quality at an early stage of pursing while slipping is still acceptable; 3) seine net designs and techniques that minimize the mortality associated with slipping. Where purse-seine gears used today are designed to maximize catch, new designs should consider the welfare of the catch and aim to minimize potentially fatal stressors and, physical injuries to the fish during the capture process.

7.1.5 Cod and haddock escape behaviour in relation to catch control devices in seine nets

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We tested different prototypes of catch control devices in the Norwegian seine net fishery for cod and haddock in March-May 2014. Fish behaviour was found to greatly vary between these two species with respect to the type of catch control device used and the stage of the fishing operation (towing at depth, haul-back operation, or at surface). Cod generally showed few escape attempts while the seine was towed at depth (despite of having openings of up to 140 cm), and remained swimming calmly inside the codend and the extension piece. It was not until late in the haul-back operation that cod showed escape behaviour through the catch control devices and the codend. The escape of cod often happened at depths between 30 and 20 m from the sea surface. At this depth the fish started releasing air bubbles due to decompression and this external factor was what triggered its escape behaviour. Contrarily, haddock showed frenetic escape behaviour as soon as they reached the area with the catch control device and/or the square-meshed codend. Few haddock attempted escape during the haul back operation. At surface, dying haddock was mostly dropping from the codend.

Lots of cod swimming calmly inside the codend and none of them attempted to escape by the catch control device (140 cm opening in the codend's lower panel; left). Many haddock escaped the seine as soon as they reached the catch control device (spaghetti; right).

7.1.6 Socio–economic impact of gear selectivity, technical measures and population structure in the Baltic cod trawl fishery.

Hans Nilsson* and Joakim Hjelm
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Discarding fish is the practice of returning dead unwanted catches to the sea. The reasons for discards are many but there is resistance from the industry to use more selective methods due to expected economic losses. In the Baltic Sea, the discard rates are considered relatively low compared to other areas of Europe, but the latest estimates suggests that discard rates for cod are increasing and can be as much as 25% in weight. Here, we use a simple economical model to explore the economic effects of two different factors (gear selectivity, minimum landing size) to reduce discards. We also use the same model to explore the effect of the imminent discard ban in the Baltic Sea but also the effect of smaller average size of cod the last 30 years. We compare the economy outcome of these four factors by comparing the individual quota for a standard Swedish Baltic vessel (trawler 18–24 meters). The economic outcome of these fore factors suggest that increased selectivity and a discard ban will have a negative impact on economy outcome but this can be compensated with a decreased minimum landing size. Our analyses also suggest that the decreasing cod size has large effect on the economic outcome and as a result, the economic incentive to reduce discards is lower now than ever before.

7.1.7 The dynamic simulation of the pelagic longline deployment

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It is very important to understand the deployment operation process of tuna longline. In this study, based on the TDR depth and simultaneous settlement data and three-dimensional ocean current data collected on the fishing vessel "Huananyu 716" near the waters of Cook Islands (10°S～15°S, 156°W～168°W) from September 2012 through November 2012, and taking into account of the hydrodynamic force of longline fishing gear float, we built the dynamic equations of tuna longline fishing gear,

solved the equation using R language programming, and carried on the verification of the model and visualization. The results showed that: (1) there were no significant difference (P > 0.05) between the hook depth measured by TDR during settlement and the predicted hook depth by variance analysis in pairs t-test, except No.1 hook (P<0.05); (2) during the deployment, the tension of most nodes was 0, the tension of the master node (No.1 hook) increased gradually, the space location change was given priority to larger current; (3) in the settlement, the tension on both ends of the node increased gradually, the tension of intermediate nodes as the nodes of the settlement had increased gradually, the hydrodynamic force affected by different sea current was relatively obvious, the space location change was priority to larger current, the settlement speed of node (1,1) and (1,30) fluctuated around (±0.5m/s), the settlement speed of node (1,15) and (2,15) fluctuated around (±2m/s); (4) using the single factor variation analysis (according to the different flow velocity), we found the tension changed in the largest (especially the velocity changed) with the sea current changed in x-axis direction; the influence of y-axis direction current took second place on longline shape, tension, etc.; the influence of Z axis direction sea current had minimum impact on longline space shape. However, the hook depth was affected by fishing gear configuration and material, operating parameters and sea conditions etc. Among them, the physical parameters of fishing gear, such as the flow and hydrodynamics around the gear system and its components, materials properties and their gravities were the important factors affecting the shape of fishing gear and hook depth.

8   ToR a): Dynamic catch control devices

Conveners: Eduardo Grimaldo, Pingguo He and Mike Pol

Current activities within the institutes of several members of WGFTFB suggest that dynamic catch control is an important issue for several fisheries worldwide. Excessive catches are an acknowledged problem that result in increased mortality, reduced fish quality, and minimized fishing opportunities. Solutions pertaining to catch control are required by the authorities and fishers of different countries.

Several countries have conducted or are planning significant studies in this field but major improvements to the solutions presented are still needed. The creation of such a group would improve the cooperation between countries and institutes and would act as a SharePoint for the progress in the field.

Excessive catches are a problem, first of all because they often exceed the processing capacity of the vessel and consequently affect the quality of the fish delivered. In fisheries supplying fish for aquaculture where the fish needs to be taken onboard alive, excessive catches present an additional problem because of the lower survival chances of the fish when excessive amounts of fish are caught. In addition, excessive catch amount can lead to serious health, safety and environmental (H.S.E) concerns. In individual or group quota fisheries, excessively large catch can lead to diminished fishing opportunity for other species.

Excessive catches have so far been related to trawls, Danish seines and purse-seines, which demonstrates that this is a global problem in fisheries. Solutions for such a global issue will contribute to more responsible fisheries worldwide and reduced unaccounted fishing mortality through the reduction of discards.

8.1   General overview

This ToR was introduced by Eduardo Grimaldo at plenary and the participants met for a 3-hour session in which several individual presentations were held. The definition of dynamic catch control was initially discussed followed by a review of the fisheries and conditions where dynamic catch control can be an advantage. Some of the drivers for using catch control devices where identified and discussed. Finally, the group defined the scope of the ToR to specifically include trawls, seines and purse-seines. David Chosid acted as rapporteur.

8.2   List of participants

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8.3 Terms of reference

The group will have the following terms of reference:

i) Review the fisheries, conditions, and impact on mortality where dynamic catch control can be an advantage and consider/share recent improvements towards commercial fisheries.

ii) Provide improvements/solutions for the challenges related to excessive catches that are encountered in the different fisheries and gears worldwide.

iii) Produce a report including a review of the status of knowledge and technology on the subject, with identification of technology gaps, and recommendations for future research on the technology for the different fisheries and fishing gears.

8.4 Individual presentations

Five individual presentations associated with dynamic catch controls were given in plenary. Two presentations focused on demersal trawling, two addressed problems in demersal seine fishing, and one provided an overview of a series of techniques used in pelagic purse seining.

8.4.1 Deep vision stereo camera system to identify, count, measure, and map a variety of species during trawling

Shale Rosen, Melanie Underwood, Darren Hammersland-White, Arill Engås, Elena Eriksen, Terje Jørgensen

Scantrol AS (Bergen, Norway) and the Institute of Marine Research (Bergen, Norway) have collaboratively developed an in-trawl stereo camera system to identify, count, and measure sizes of organisms passing through a trawl. The system, Deep Vision, collects five sets of colour images per second capturing everything passing through the aft section of the trawl. It has successfully collected quantitative data on individuals ranging from young of the year fish and zooplankton as small as 2 cm to adult Atlantic cod over 100 cm in length. Fragile species that are normally destroyed in trawls, such as small jellyfish, can be imaged earlier in the trawl, identified, and quantified. Sampling has also been conducted with an open codend, demonstrating the potential to conduct trawl sampling without killing the individuals. The images are time- and depth- referenced, making it possible to reconstruct the precise three-dimensional position of each individual as well as the passage rates throughout the period of trawling. Future work will integrate the species and size results with detailed acoustic echogram data.

8.4.2 Escape slots in front of a demersal seine codend combined with a new "Fish lock"

Ólafur Arnar Ingólfsson, Bjørn Totland, Jostein Saltskår, Shale Rosen.

Fishers, gear manufacturers and researchers have worked together to test and film a gear solution that limits catches in demersal seines on board a commercial vessel. Two 1.75 m long and three mesh wide openings were cut in the top part of a codend extension. Nylon ropes, 10% shorter than the circumference of the openings, were threaded along the edges of the openings. The shorter ropes keep the slots closed early in the tow and when the volume of catches are small, but will allow the slots to expand as the volume of catch in the codend builds up; once the slots are expanded, residual catches can escape through the openings. The codend itself chokes to retain predetermined catch volumes. A new design of a "Fish-lock" keeps fish trapped in the codend preventing them from floating out through the large openings at the surface. The Fish-lock is a three-metre long netting cylinder, positioned just behind the escape slots, inside the codend extension. A choking strop is threaded around the mid-part of the cylinder and attached to the selvedges of the extension. When catch volumes build up and the extension expands, the choking strop chokes the cylindrical netting and blocks passage.

The escape openings in front of the choking strop and ac-cumulated fish at the surface. The Fish-lock traps fish in the codend (the red netting).

The demersal seine fleet has gotten an experimental dispensation until the end of year 2014 to use this system. The solution has gained industrial acceptance and fishers are able to control catch quantity fairly accurately. An introductory video is available at IMR's YouTube website (https://www.youtube.com/watch?v=gco3WXd51TY).

8.4.3 Excess Fish Exclusion Device (ExFED): How to passively release fish at depth during trawling.

Melanie Underwood, Arill Engås, Shale Rosen, Asbjørn Aasen (Institute of Marine Research, Norway).

Historically high populations of Atlantic cod in the Barents Sea are currently leading to excessively large trawl catches. This leads to reduced quality when the catch exceeds vessels' production capacity, increased risk of discarding, gear damage and safety concerns. Therefore, a passive system was developed to limit the maximum catch volume.

The Excess Fish Exclusion Device (ExFED) consists of a fish lock just behind a rectangular hole in the upper trawl panel covered by a mat attached only at its leading edge. The fish lock prevents the targeted quantity of fish from escaping during haul back. Initially, the mat rests lies against the top panel of the trawl sealing the hole. As fish accumulate and fill up to the fish lock, water flow is diverted out the hole, forcing the mat open and allowing excess fish to escape at the fishing depth. The system is mounted at a predetermined distance from the cod line to achieve the target catch volume for the vessel.

Six Norwegian vessels were given approval by the authorities to use ExFED during commercial fishing in 2013. The system design was improved based upon feedback from the commercial fleet and gear researchers. Based upon their success to date, industry, managers, and researchers have agreed to further develop and test the system in additional trawl designs on additional commercial vessels during commercial fishing in 2014.

8.4.4 Catch control measures in purse-seine fisheries in Norway

Mike Breen, Bjørnar Isaksen, Egil Ona, Audun O. Pedersen, Geir Pedersen, Jostein Saltskår, Benny Svardal, Maria Tenningen, Peter J. Thomas, Bjørn Totland, Jan Tore Øvredal, Aud Vold.

The release or "slipping" of schooling species like mackerel (*Scomber scombrus*) and herring (*Clupea harengus*) in the later phases of hauling during purse-seine fishing has been shown to induce high mortality among the released fish. Slipping occurs in these fisheries due to unsuitable catches, with respect to species compositions, small fish size and/or quality, or excessively large catches. In 2011, Norway introduced regulations banning the deliberate release of fish in the later retrieval stages of the purse-seine haul in an attempt to minimize the unaccounted or collateral mortality from these fisheries. A mitigation program has been launched in Norway that aims to provide fishers with tools that will minimize the need for slipping and, where slipping is unavoidable, maximize the survival of "slipped" fish. The program focuses on three main areas of development: 1) acoustic instrumentation for improved pre-catch identification of fish schools (in terms of species, quantity and fish size) to prevent catching unwanted fish; 2) methods and equipment to estimate the catch volume, fish size and quality at an early stage of pursing while slipping is still acceptable; 3) seine net designs and techniques that minimize the mortality associated with slipping. Where purse-seine gears used today are designed to maximize catch, new designs should consider the welfare of the catch and aim to minimize potentially fatal stressors and, physical injuries to the fish during the capture process

8.4.5 Cod and haddock escape behaviour in relation to catch control devices in seine nets in Norway

Eduardo Grimaldo, Manu Sistiaga, Jørgen Vollstad, Roger B. Larsen

We tested different prototypes of catch control devices in the Norwegian seine net fishery for cod and haddock in March-May 2014. Fish behaviour was found to greatly vary between these two species with respect to the type of catch control device used and the stage of the fishing operation (towing at depth, haul-back operation, or at surface). Cod generally attempted few escapes while the seine was towed at depth (despite having openings of up to 140 cm), and remained swimming calmly inside the codend and the extension piece. It was not until late in the haul-back operation that cod performed escape behaviours through the catch control devices and the codend. The escape of cod

often occurred at depths between 30 and 20 m. At this depth, the fish started releasing air bubbles due to decompression that triggered the escape behaviours. Contrarily, haddock showed frenetic escape behaviour as soon as they reached the area with the catch control device and/or the square-meshed codend. Few haddock attempted escape during the haul back operation. At surface, dying haddock were mostly dropping from the codend.
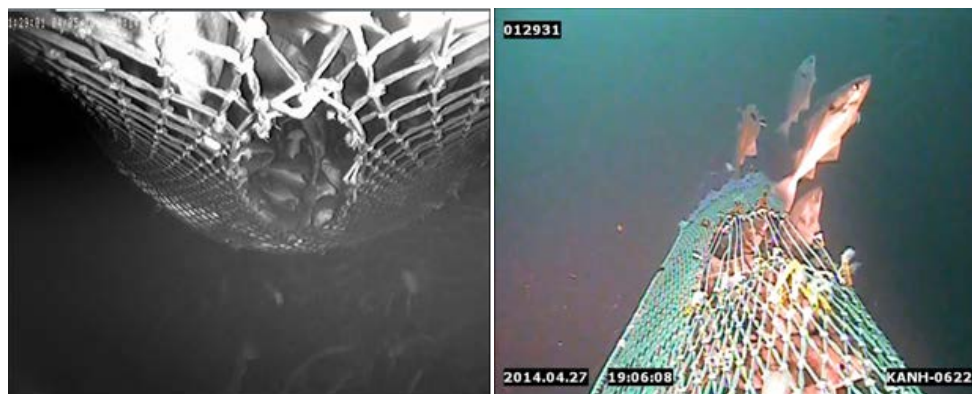
Many cod swimming calmly inside the codend and none of them attempted to escape by the catch control device (140 cm opening in the codend's lower panel; left). Many haddock escaped the seine as soon as they reached the catch control device (spaghetti; right).

8.4.6 Main Outcomes

- The group recruited expertise on seine net fisheries in regard to control of big catches.

- The group reviewed a series of techniques for controlling the catch in seine net fisheries for cod and haddock. Differences in fish behaviour in respect to fish escape through the catch control device were found to be important when designing such devices. The group discussed implications of cod escape from the seine net during the haul back operation, often associated with decompression stimulus, and its implications to fish survival.

- The group recruited expertise on purse-seine work in regard to identifying species and releasing unwanted species and undersized fish.

- The group reviewed several techniques that have been tested in the Norwegian purse-seine fisheries for catch controls of mackerel and herring. These techniques have focused on three main areas of research: 1) acoustic instrumentation for improved pre-catch identification of fish schools (in terms of species, quantity and fish size) to prevent catching unwanted fish; 2) methods and equipment to estimate the catch volume, fish size and quality at an early stage of pursing while slipping is still acceptable; 3) seine net designs and techniques that minimize the mortality associated with slipping.

- The group identified technology gaps and weaknesses that include identification of codend catch volume, image/video wireless transmission; automated codend closing device reliability and resetting time, cost of devices (not technically a technology gap), and catch sampling of purse-seines.

- The group made a working plan for the elaboration of the ToR's final report that will be delivered at next year's WGFTFB meeting.

8.4.7 Recommendations

The ICES-FAO WGFTFB Topic Group on Dynamic Catch Controls makes the following recommendations to the ICES-FAO WGFTFB:

- Collaborations that have been established between members should continue outside the context of meetings of WGFTFB.
- The group will work by correspondence to complete the ToR's final report for delivery at the 2015 WGFTFB meeting.

9 ToR b): Future applications of artificial light in fishing gear design and operations

Conveners: Heui Chun An and Anne Christine Utne Palm

9.1 General overview

It is thought that artificial light, in the form of fire, has been used in fishing for thousands of years (Ben-Yami, 1978). In the presence of artificial light, pelagic fish often school and move towards the light source and this technique is successfully employed in several fishing methods (Ben-Yami 1978; Gabriel *et al.*, 2005). Commercial applications of light in purse-seines, lift nets, and squid jigging are widely practiced, especially in Asian-Pacific countries. In jigging, hook and line, dipnet and purse-seine fisheries, artificial light sources are used to attract and aggregate squid and pelagic fish such as sprat, herring and mackerel (Ben-Yami, 1988). In longlining, light-sticks are widely used to encourage swordfish to ingest the baited hook (Hazin *et al.*, 2005). Indeed, there are few fishing practices in which light is not sometimes used to attract or concentrate fish, and few fishing gears that are not sometimes used in combination with light to attract the fish (Gabriel *et al.*, 2005).

Today, fire and gas lamps have been replaced by incandescent lamps, metal halide lamps or fluorescent lamps as the source of light these fisheries. While more convenient, safer and significantly more powerful, with respect to the light emitted, these lamps have generated new problems for the light fisheries in which they are used. First, competition between boats and métiers has led to an excessive level of light output from many established fisheries (Matsushita *et al.*, 2012). As a result, the vessels incur increasing fuel costs and have an increasing environmental impact, in terms of light pollution and CO_2 emissions. Furthermore, this excessive level of competition, if unchecked, could easily generate a technological creep in catch per unit of effort and thus lead to overfishing.

Commercial applications of artificial light for fishing have tended to be confined to surface or subsurface lights in fisheries that target pelagic and schooling species. Technological limitation partly explains the lack of application in demersal and deep-water fisheries. Light systems operated at greater depths have mainly used battery packages for energy supply because cables were impractical. These batteries were heavy and with a comparatively short life time and therefore not very suitable. How-ever, recent technological advances in battery and modern LED light technologies (Inada and Arimoto, 2007) have made available small, robust, powerful and energy-efficient light units that can be used in deeper waters for both static (e.g. pots and longlines) and towed fishing gears (e.g. trawls). Moreover, these new energy efficient light sources are continuing to develop and may be used to develop energy efficient and environmentally friendly fishing technologies for existing light fisheries.

Many explanations have been offered to explain why fish respond to light, including conditioned responses to light gradients, curiosity, social behaviour, phototaxis, optimum light intensity for feeding, and disorientation and immobilization due to high light levels (Arimoto *et al.*, 2011). However, despite many years of research into fish visual systems, knowledge of the role of vision in the capture process is still limited. The functional explanations for responses to light, whether repulsion or attraction, include predator avoidance and enhancement of feeding efficiency (Pitcher and Parrish, 1993). The type of responses and their functional explanations depend on species, ontogenetic development, ecological factors, and physical characteristics of the light source (intensity and wavelength; Marchesan *et al.*, 2005). As technological improvements enable research into the responses of species previously unexposed to artificial light (i.e. in demersal and deep-water fisheries), there is great potential for developing innovative solutions to longstanding bycatch and selectivity challenges using artificial light.

A synthesis of the knowledge of light fishing and the fundamental responses of fish to artificial light will provide a comprehensive overview of the topic and stimulate research into the innovative application of artificial light; in both established light fisheries and in demersal and deep-water fisheries, where the technology remains relatively untested. There is considerable potential for artificial light to be used constructively in the development of more efficient and responsible fishing methods. This ICES-FAO Topic Group on the Use of Artificial Light in Fisheries offers an important opportunity to combine and coordinate the research activities of scientists from the ICES community, with an interest in developing light as innovative technique, with scientists from the FAO community (particularly Asia), who have a great deal of experience working with traditional light fisheries.

9.2   List of participants

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9.3 Terms of reference

"A WGFTFB topic group of experts will be formed in 2012 to evaluate present and future applications of artificial light in fishing gear design and operations. The group will work through literature reviews, questionnaires, correspondence and face-to-face discussions.

Specifically the group aims to:

i) Describe and summarize fish response to artificial light stimuli;

ii) Describe and summarize use of artificial light in world fisheries;

iii) Describe and tabulate different light sources to attract fish;

iv) Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions; and

v) Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods."

vi) Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture.

9.4 Individual presentations

It was decided at the beginning of the FTFB meeting that some presentations meant to be given under the different working group sessions should be given at plenum sessions, as they would be of interest to a broad audience of FTFB. The first two here were plenum and the final four to the topic group.

9.4.1 Application of the low-power underwater light to a large-scale trap-net fishery. Sonar observation and tagging experiment.

Daisaku Masuda, Masahiro Maeda, Shuya Kai, Yoshiharu Sasamoto, Yoichi Yanagino, Kei-ichi Furukawa and Yoshiki Matsushita.

The fish attraction system consisting of a 55-W underwater discharge lamp and a surface buoy that contains batteries was tested for the purpose of improving the catch efficiency of the large-scale fish-trap and reported in the FAO-ICES mini-symposium at Bangkok. This is a follow-up study to investigate fish behaviour. Here we observed fish behaviour around the trapnet by using a scanning sonar. Fish schools were frequently observed around the lamp during illumination and they moved to the entrance of the trapnet when the lamp was turned off. We also released tagged jack mackerels before, during and after illumination from three different locations. The recapture rate of jack mackerel released during illumination was higher than for other time periods.

Underwater illumination helped fish stay around the trapnet and consequently improved the capture performance of the trapnet gear.
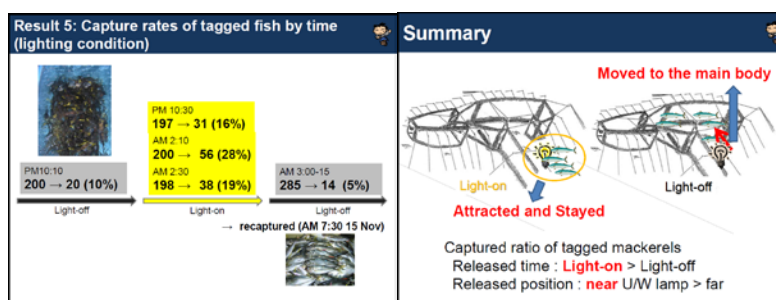
9.4.2 Addition of light to an experimental footrope caused increased escapement of one flatfish species

Craig S. Rose and Carwyn F. Hammond

Trawl modifications to reduce damage to seabed animals also need to maintain catch rates of target species. The FishSkimmer, an experimental trawl footrope component, was designed to reduce damage by being movable upon contact with stationary objects, while still maintaining visual and tactile stimuli for fish capture. To test if visual stimuli were usefully increased by adding an LED light (http://www.lindgren-pitman.com/c-4-electralume-battery-powered-fishing-lights.aspx) to each FishSkimmer device, tows of a trawl equipped with auxiliary nets to capture fish passing under the footrope were made with and without lights installed. Addition of lights had no significant effect on escape rates of one species of flatfish (flathead sole, *Hippoglossoides elassodon*) and a roundfish (Alaska pollock, *Gadus chalcograma*). However, they had a dramatic effect in a direction opposite to expectations (approx. 3X more escapes) for another flatfish species (southern rock sole, *Lepidopsetta bilinetata*).

9.4.3 Biologist guide to light and its measurement

Michael Breen

In this talk, Mike Breen reminded everybody again on what light is and what units light should be measured in to make biological sense (in terms of what triggers a fish's photoreceptors). We shall measure light in radiometric units no of photons (µE) energy (J) or power (W) and not photometric units like lux, lumen and candela as these are based on what the human eye can perceive (humans psycho-physiological perception of light). Further, as visual light (image-forming-light) is only that light that goes straight to the eye (without being scattered or absorbed on the way) one should measure directional light – radiance (use a flat sensor – preferably with a *Gershun tube*). For an alga which can take up light all over its spherical surface, independent of which

direction it comes from or whether scattered or not irradiance will be the appropriate measuring unit (a spherical sensor).

9.4.4 Marine optics

Yoshiki Matsushita

In this talk, Yoshiki Matsushita described the essentials of Marine Optics. Water absorbs light much more than air. Additionally to the water itself, inorganic (clay) and organic particles (phytoplankton) in the water enhance the absorption and scattering. The absorption depends on the wavelength and water types (oceanic -, coastal -, brackish - water etc.). The light distribution of a light source is not uniform spatial distribution of a light source is generally explained with a virtual sphere.
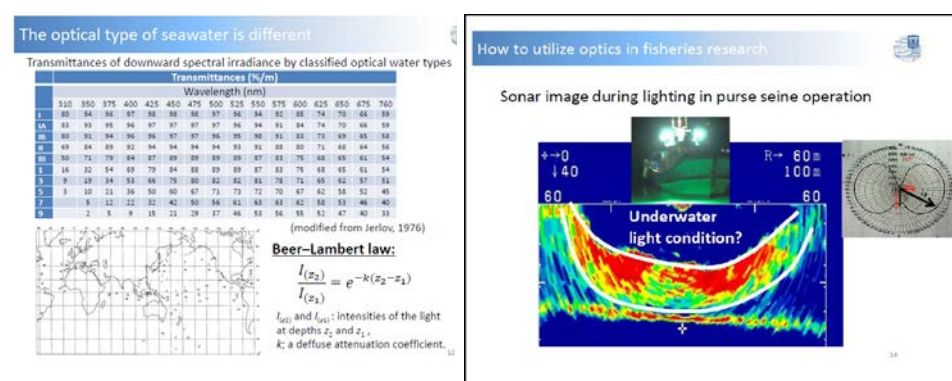
Matsushita also demonstrating how radiometric light measurements could be estimated from photometric measurements, given the right conditions and sufficient information about the light source and properties of the medium.

9.4.5 A brief overview of light fisheries in Asia

Heui Chun An

Heui Chun An presented a brief overview of light fisheries in Asia today, where it is used in Dipnet fishing for Saury, scoop net for Anchovy, purse-seine, beach-seine, gill-nets and set-nets.
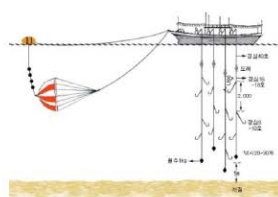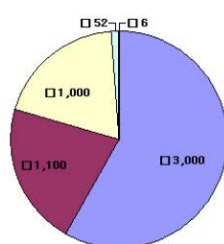
Squid Jigging

Hairtail Angling

Anchovy Scoop Net

Purse Seine
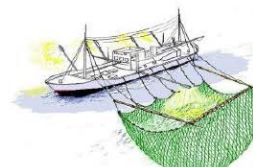
Stick-held Dip Net
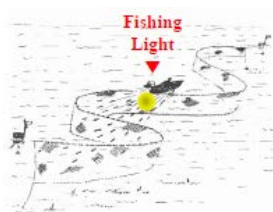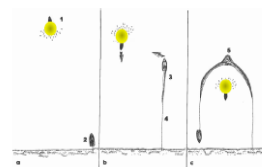
Gillnet   **Set-net**   **Beach-seining**

9.4.6   Light fishing activity observed by NASA satellite

Takafumi Arimoto

Takafumi Arimoto showed some pictures of light fishing activity taken by NASA satellites during night. These types of pictures compiled from satellite cameras, are available NASA's web page.

9.5   Discussion

This was the third meeting of the Topic Group on the Use of Artificial Light in Fisheries. The ICES-FAO WGFTFB presented an idea forum in which to coordinate the research activities of scientists from the ICES community, with an interest in developing light as innovative technique, with scientists from the FAO community (particularly Asia), who have a great deal of experience working with traditional light fisheries. Last year's meeting was held in Bangkok, Thailand, to facilitate the development and work of this group, by opening lines of communication with experts in Asia working in the field of light fishing. A mini symposium on the use of artificial light in fisheries was also held during last year's meeting, a meeting that was focusing on ToR 5 and 6.

Being established as a three-year working group this WG should have finished its work by 2014, however, despite a very successful meeting in Bangkok last year, there has been little progress on the ToR's over the last year. Therefore the co-chair of the ICES-FAO WGFTFB, Pingguo He, gave us one more year (until next meeting 2015) to fulfil the ToR's.

We believe that the little progress since last year is based on the fact that very few of the working group members were assigned tasks (9 of 53 in total). Therefore, one important task for this year's meeting was to include more of the group participants in the ToR – after all, it is a working group where everybody should contribute. Besides assigning more people to the remaining tasks an important job was to make a time line for the different ToR's - so that they would be finished by next year's meeting.

9.5.1 Publications

An important and motivating factor in our work is to get the WG achievement out to the public in forms of publications. Thus, alternative publications were discussed both in the WG it-self and in the FTFB as a whole. Publishing the main findings of the ToRs as a FAO book was one suggestion that came up. However, the WG members seemed sceptical of this suggestion as this is known to be a slow publishing process (can take years). A second alternative that was discussed was an ICES Cooperative Research Report. Thus, in the group, we agreed on gathering our findings into a couple of publications if good enough, and we tried to identify candidates. The following was suggested: i) A guideline to implementation of artificial light in fisheries; ii) A review on the use of artificial light in fisheries; iii) Review of fish behaviour towards artificial light, with focus on commercial species; iv) Review of fish visual pigments, with focus on commercial species. It was also suggested that the latter two be merged to one review.

Another topic that was discussed was our group's use of Group Net. Few were using the group net at the moment. One problem that was identified was that the group members were not happy with the new group net version, and very few have managed to make themselves familiar with the new program. Files were lost after the new shear point program was introduced – Michael Breen promised to add all the old files to the new Group Net program, so that we can get back on track.

9.6 Main Outcomes

The main outcomes of the discussion of the ToR progress are given below and the status is indicated as being "Completed", "In progress", or "Needs attention".

ToR 1: Describe and summarize fish response to artificial light stimuli

- Task - Marine Optics – essential elements for fisheries biology (Yoshiki Matsushita (YM) *et al.,*) Status: Completed.

To provide a background summary to ensure the reader has sufficient understanding to appreciate the properties of light in water and hence the physical limitations of using light in fishing.

- Text completed and submitted.
- Matsushita also gave a very interesting presentation demonstrating how radiometric light measurements could be estimated from photometric measurements, given the right conditions and sufficient information about the light source and properties of the medium. Mike Breen (MB) will follow up on this when completing the light measurement text.
- Task - Visual spectrum (retinal pigments) of different species (Anne Christine Utne Palm (ACUP) *et al.,*) Status: In progress.

To provide a background summary to give the reader an introduction to the biology (form and function) of vision in aquatic organisms. This will highlight the limitations of the vision underwater, in particular with respect to their spectral sensitivity, and provide some insight into the perception of light in the underwater environment.

- ACUP has conducted a literature search and identified a number of useful papers. Unfortunately, many of these are written in Japanese – so to complete this task it will be essential to recruit some of our Japanese colleagues onto the task. Prof Takafumi Arimoto (TA) and YM said they would try to provide some support. Prof TA said if he gets the papers soon he will try to work quickly on providing a summary.
- ACUP stated this work should just focus on commercial species (and maybe important prey species? E.g. cod and krill?).
- ACUP will also try to involve Prof Ronald Kröger or someone from his Vision group at Lund University, Sweden.
- ACUP will aim to have a draft ready for late Oct 2014
- Task - Behavioural responses to light (Svein Løkkeborg (SL) *et al.,*) Status: needs attention.

The use of light in fishing is dependent upon emitting light (in whatever form) with the purpose of stimulating and manipulating a behavioural response from the target species that will promote their capture. This review will summarize the available literature on behavioural responses in commercially important species, as well as potential prey species.

- There has been no progress on this review -> SL said this was primarily because he has no time to allocate to it.
- MB suggested that it might be possible to combine this review (and the visual pigments) with the application to NFR planned for Sept 2014? - > so his time could be allocated to the application.
- Craig Rose (CR) said he would contact Lionel Brit, who may be able to contribute in some way to the review.
- SL will aim to have a draft ready for late Oct 2014
- In support of these reviews, and other associated research, the group has established a database of relevant literature.

ToR 2: Describe and summarize use of artificial light in world fisheries

- Task - Identify Regional Correspondents to produce regional reports/overviews of light fishing (MB). Status: in progress.
  - The first year of the TG generated some useful information, particularly from Asia (see tables in 2012 report), but this has progressed little since then.
  - In particular, there is a lack of data for the Americas. But Frederico Iriarte (FI) and Mark Szymansk (MS) said they might be able to help with this knowledge gap – or at least provide useful contacts.
  - There was some discussed on whether we should include additional information in the tables, in particular the colour of the lights and whether the use of light is controlled by regulations.
  - MB will recirculate the tables (with addition columns for colour and regulations) to all members to update previous data or to fill in gaps.

- Task - Produce a summary description of light fishing techniques – industrial and artisanal (Yingqi Zhou and Heui Chun An (YZ and HCA). Status: needs attention.
    - No progress has been made with this. Yingqi Zhou (YZ) was tasked with this in 2013, but has now retired.
    - HCA has again already given excellent presentations giving overviews of the various techniques used in Korea (which incorporates most of the commercial techniques used worldwide). He has volunteered to try to put some text together but is concerned about his English. He was assured this would be addressed during the editing.
    - A number of new members have committed to contributing too: **Shannon Bayse, Corinne Endres, Gokhan Gokce, Mochammed Riyanto** and **Emilio Notti**.
    - NB FAD lights for Tuna -> from FI
    - We would recommend getting one of the new members to drive this. It may be too much to expect HCA to take on two tasks (see below).
- Task - Investigate the feasibility of using satellite imagery to support a global review of light fishing (Bjørn Erik Axelsen (BEA), Pingguo He (PH) and YM). Status: in progress.
    - YM has written a small amount of text based on dialogue he had with the Japanese Space Agency. There was some discussion at the meeting saying that the technologies available to contact this work are limited by availability and cost – as most suitable camera systems are for military use (YM referred to USAF being the main source of information).
    - There was also discussion about conversations with Dan Watson (DW), who is now working for a UK Space Agency developing commercial use of new technologies. He has said he will provide contacts with colleagues who may be able to support us with this section. He also suggested that maybe the most informative approach would be to have a database of the light source types on each vessel, than use VMS data (satellite based) to assess the distribution of light fishing and power.
    - Prof TA should some video, publicly available for NASA's web links, compiled from satellite cameras (Get web links from Prof TA).
    - We briefly discussed pressing BEA to take the lead on completing this task – he was originally committed to the review.

ToR 3: Describe and tabulate different light sources to attract fish

- Task - A technical review of the sources of light applicable for use in fisheries (Heui Chun An (HCA)) Status: in progress.

To provide a background summary to give the reader an introduction to the available and emerging technologies for the production of light. The advantages and limitations of using the different technologies in fishing will be highlighted.

- HCA has already presented some very useful overviews of the various lighting technologies and their history of development in Asia. He is prepared to put some text together – but is concerned about his English (see previous notes).

- Prof Jang (who presented in Bangkok in 2013 on LED tech) could be recruited to write a small section on LEDs --> HCA will approach him.

- Dan Watson (DW) was also prepared to contribute to this – particularly with the possible development of UW lighting technologies.

- Emilio Notti (who has an engineering background) also expressed an interest in contributing on this topic

- We hope **Dan Watson or Emilio Notti** can step up and drive this. As it is too much to expect HCA to take on two tasks (see above).

ToR 4: Describe challenges of current use of artificial lights in fisheries and identify/suggest potential solutions. Status: in progress.

- There has been no real progress on this and no one has been identified to take the lead. However, this should not be a large task, which would greatly benefit from reviewing the work YM and HCA have been doing.

- Note from 2013 -> Need a more comprehensive global overview of the light fishing sector.

- Gokhan Gokce also rose the point that shouldn't we discuss here, why light is used in the first place. It was explained that it primary use has been to attract and concentrate fish to promote capture. This effectively increases fishing effort/catchability.

- Another suggested use was for selectivity – but it was discussed that there are no known effective examples yet. [However, see note from Dr Fieldhouse, University of Tasmania, Australia].

ToR 5: Identify new and innovative applications of artificial light in attracting, guiding, and repelling fish in developing bycatch reduction devices and other sustainable fishing methods."

- Task - Innovative Use of Light in Fishing (Pingguo He *et al.*): Status: in progress.

To provide a review, complimentary to the review on the behavioural responses of commercially important species to light (ToR 1), with the purpose of providing guidance on the constructive, selective and innovative use of these behavioural responses/manipulations in the fish capture process.

- Pingguo He (PH) was initially tasked with coordinating this, but there has been little progress since.

- He made an excellent introductory lecture on the subject at the first meeting, which was summarized by MB in the first report. Maybe this text could be used as a basis for the report and developed with PH and others?

ToR 6 (Additional): Provide guidance on conducting experiments to investigate the use of artificial light as a stimulus in fish capture

- Task – Review light measurement protocols and instrumentation requirements (Michael Breen and Amit Lernar (AL) Status: in progress.

- Presentation completed with Amit Lerner and presented to TG in 2013 and 2014.

- Text for report is underway, but with current workload, MB cannot re-look at it until later this year. MB will attempt to have a draft ready for Late Oct or late Dec, depending on other commitments.

- YM also gave a very interesting presentation demonstrating how radio-metric light measurements could be estimated from photometric meas-urements, given the right conditions and sufficient information about the light source and properties of the medium. MB will follow up on this when completing the light measurement text.

- Task – investigate the feasibility of establishing common facilities for the measurement of light irradiance and transmission (MB) Status: completed.

  - Done, informal discussions and agreement with Howard Browman to use facilities at Austervoll for collaboration initiatives. --> Incorporate in review of light measurement.

  - Suggest recirculating concept to all members to identify other facilities were this approach could be adopted (no need to develop formal com-mitment from host institute).

9.7 Recommendations

The ICES-FAO WGFTFB Topic Group on the Use of Artificial Light in Fisheries makes the following recommendations to the ICES-FAO WGFTFB:

The Topic Group on the Use of Artificial Light in Fisheries will continue working by correspondence to give its final report at the next WGFTFB meeting in 2015.

10   ToR c): Relationships among vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries

10.1 General overview

The huge variety on fishing gear characteristics, between and within member states, poses a challenge to the EU need for implementation of standardized gear-based management tools to avoid overfishing of the European Seas. Fishing gears for the same fishing technique among different countries and stock areas can be quite different, mainly due to different specifications in design and materials used. Different depth, seabed and other environmental characteristics also seem to bring about different trawl gear designs. Despite the availability of innovations in fishing gear design, new technologies seem to have difficulty in spreading freely and in many areas; fishing gear deployment is far from state-of-the-art technology. There is an urgent need of a standardized methodological approach to the description and information sharing with respect to fishing gear specifications and developments – both in terms of policy needs and in order to highlight and disseminate best/optimal relationships among major gear parameters and between gear and vessel.

The aim of the ToR C is to assess a series of relationships between vessel characteristics and gear specifications in commercial fisheries, with a focus on European fisheries, in order to establish maximum dimensions and adequate rigging for trawl fishing gears. A comprehensive standardized knowledge base for all these elements will contribute to improve the selectivity, to optimize the fishing effort and to minimize the environmental impact of fishing gears. Such information can be useful to evaluate the potential harvesting pattern of different gears in terms of explored area during fishing operations and thus contributing to specific management measures of fishing capacity.

10.2 List of participants

In order to address the topic, participants have not met in a formal WGFTFB meeting but worked by correspondence during the last year. Outcomes have been presented by Antonello Sala at the TOR summary meeting. A full list of participants at the ToR C is given below in alphabetic order.

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10.3 Discussion

Empirical relationships among different parts of the trawl gears, including different type of likely attachments, as well as between some of these parts and the otterboard size and the engine power of the vessel have been developed. The data collection has been carried out mainly within the EU-projects 'MyGears' (Figure 10.1) (http://mareaproject.net/contracts/8/overview/) and 'BENTHIS' (www.benthis.eu) where the information was collected and/or measured in relevant European fishing fleets with the collaboration both of the fishing sectors and of the control/inspection bodies.

Information has also been collected through interviews with netmakers, door manufacturers and fishers. Literature information as well as results from research projects and studies, funded either with national or/and EU support, have been used in view of establishing synergies among different scientific domains while avoiding duplications. Data collected, were processed by a customized database that allowed for dynamic parameters simulation (e.g. horizontal net opening, door spread, gear drag etc.) on the basis of geometrical and mechanical information inserted.

According to the specific objectives of the ToR C the following outcomes have been achieved:

- Collection of information from various literature sources relevant to describing the different types of European trawl gears and fishing vessels (e.g. peer review as well as grey literature, reports, etc.);
- Identification and selection of appropriate gear metrics to be used in the direct measurement of the size of nets and in the examination of the relationships between gear and vessel metrics;
- Collection and harmonization of the information obtained into a database that can be used as a first basis for quali-quantitative analysis, and decision support.
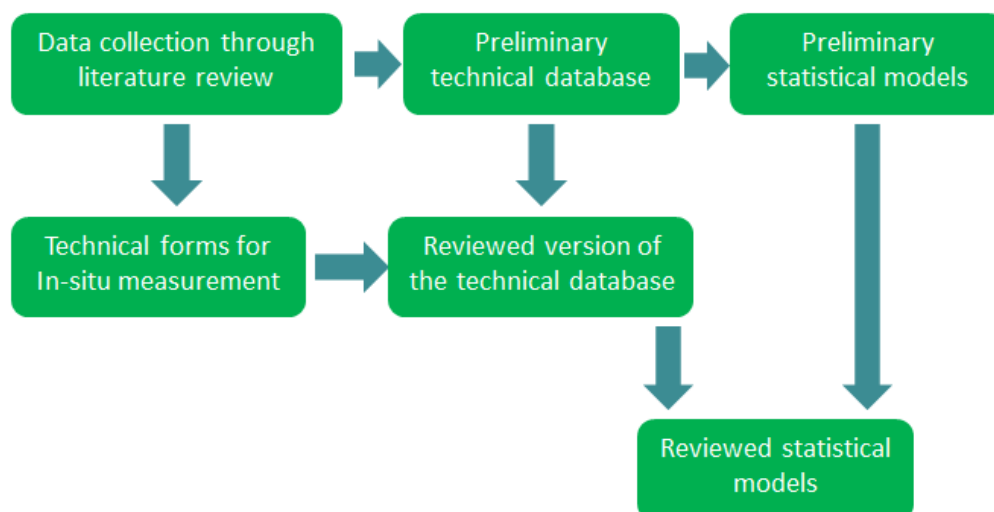
Figure 10.1. Project MyGears layout. Main goals of the project are a complete data archive for trawl gears in the Mediterranean Sea and models to relate major components of the gears and to relate the gear with the vessel.

10.4 Main Outcomes

10.4.1 BENTHIS framework for assessing fishing pressure

In order to classify and map European fishing activities according to sea bed pressure it is necessary to go into detail with the gear types and sizes deployed and the catch processes (target species) that govern the design and use of particular gears (i.e. the degree of bottom contact of the gear), as well as the appropriate spatial and temporal scale of measuring fishing activity.

The gear specifications available in the official EU fisheries statistics, the logbooks, are limited and not well suited for estimating the bottom contact of the gears. Consequently, a true and fair large-scale mapping and classification of seabed impact from EU fishing activities requires additional gear data, such as trawl door type and groundgear length, to be included. As collection of such data are not feasible on a single trip or vessel basis, other approaches have to be developed to overcome the gear specification deficiencies of the official statistics.

In the BENTHIS project the solution for incorporating quantitative information of gear-seabed interactions into the logbooks is to first classify the logbook observations in functional gear groups (i.e. DCF métiers) on a trip basis, second identify appropriate proxies for gear size by functional group (e.g. through parameterizing the relationship between engine power and wingend spread for different otter trawl fisheries) using questionnaire data from industry surveys, and third to assign quantitative information of bottom contact to each logbook trip by converting proxy values into measures of gear size.

Having extended the logbook observations with quantitative information of gear composition (e.g. door spread) it is possible to estimate the frequency and severity at which the seabed is impacted in a given area. For logbook trips where VMS data are obtainable, the trawling intensity and benthic impact can be expressed at a fine spatial scale and where VMS data are not available; the impact can be expressed on a more crude scale (e.g. the ICES rectangle scale). The BENTHIS framework for estimating fishing pressure on the benthic habitats is visualized below (Figure 10.2).

Logbooks of all European vessels, mandatory for vessel length above 10 meter would hold information of the gear size used for each logbook observation of effort and catch, which could be merged with VMS data to provide swept-area evaluation at a high resolution spatial scale. Unfortunately, only gear type (OTB, DRB and TBB) is currently informed in the logbooks and no details at all are given on gear size. This is a major shortcoming when using logbook information of effort to estimate and map fishing pressure from demersal towed gears.

In BENTHIS this logbook deficiency of gear size information is mitigated by a stepwise solution for incorporating quantitative information of gear-seabed interactions into the logbooks. The first step is to classify the logbook observations in functional gear groups (e.g. DCF métiers) on a trip basis; the second step is to identify and appropriate proxies for gear size by functional group (e.g. the relationship between vessel engine power and door spread for each of the otter trawl typologies described above) using questionnaire data from industry surveys; and the third step is to assign quantitative information of bottom contact to each logbook trip by converting proxy values into measures of gear size.

Based on the above considerations of catch principles and corresponding gear design focus in combination with the EU-DCF standardized métier categorization the following gear/fisheries groupings were identified for further analysis:

1) Otter trawling for demersal fish: OT_DMF (plaice, cod, haddock, hake, saithe, etc.)

2) Otter trawling for crustaceans: OT_CRU (Nephrops, Pandalus)

3) Otter trawling for small pelagic fish: OT_SPF (sandeel, sprat)

4) Otter trawling for mixed demersal species: OT_MIX (any mixture of the above)

5) Beam trawling for demersal fish: TBB_DMF (plaice, sole, cod, etc.)

6) Beam trawling for crustaceans: TBB_CRU (Crangon)

7) Demersal seining for demersal fish: DS_DMF (Plaice, cod, etc.)

8) Dredging for molluscs: DRB_MOL (mussels, scallops, oysters, etc.)

For the otter trawls it is possible to distinguish between towing modes (single, twin, pair) in the logbooks and potentially the four otter trawl groupings above could be further divided into trawling modes to gain precision in the proxies for gear width. Whether such a further segregation of gear groups is useful will be easier to decide once the statistical analyses of the industry data have been completed. In this decision, it needs to be acknowledged that a number of experts attending the WP2 workshop put forward that in their national logbook data the assignment of individual observations to any of the three categories (OTB, OTT, and PTB) is considered highly uncertain. The questionnaire developed to collect the industry information needed to parameterize the relationship between vessel size and gear size by métiers has been presented, over the summer and early autumn of 2013, to a selection of fishers and netmakers in all regions covered in BENTHIS. Table 10.1 shows the response up to date.

The observations were grouped according to the agreed target species assemblages (closely mimicking DCF level 5 métiers) and a number of relationships between vessel size and gear size were plotted (Figures 10.3 to 10.7). The plots revealed a number of potential proxies for the size of the different gear components. Engine power appeared to be strongly correlated to door spread, sweep length, door weight, clump-weight, and groundgear length for primarily the single species fisheries. When the inventory

of vessel-gear observations is complete, more thorough statistical analyses of these relationships will be conducted to deliver parameter values, which can be used to assign quantitative information of gear size to the logbook observations for otter trawl trips. In a similar approach, proxies for gear size have been established for the other major groups of towed demersal gears identified above.

Final outcomes will be presented by Ole R. Eigaard at the forthcoming ICES Symposium *"Effects of fishing on benthic fauna, habitat and ecosystem function"* in the session *"Fishing Gear Selectivity and Selective Fishing: Means, Methods and Implications"* (Tromsø, Norway 16–19/06/2014) with the presentation *"Estimation of seabed impact from demersal trawls, seines and dredges based on gear design and dimensions"*.
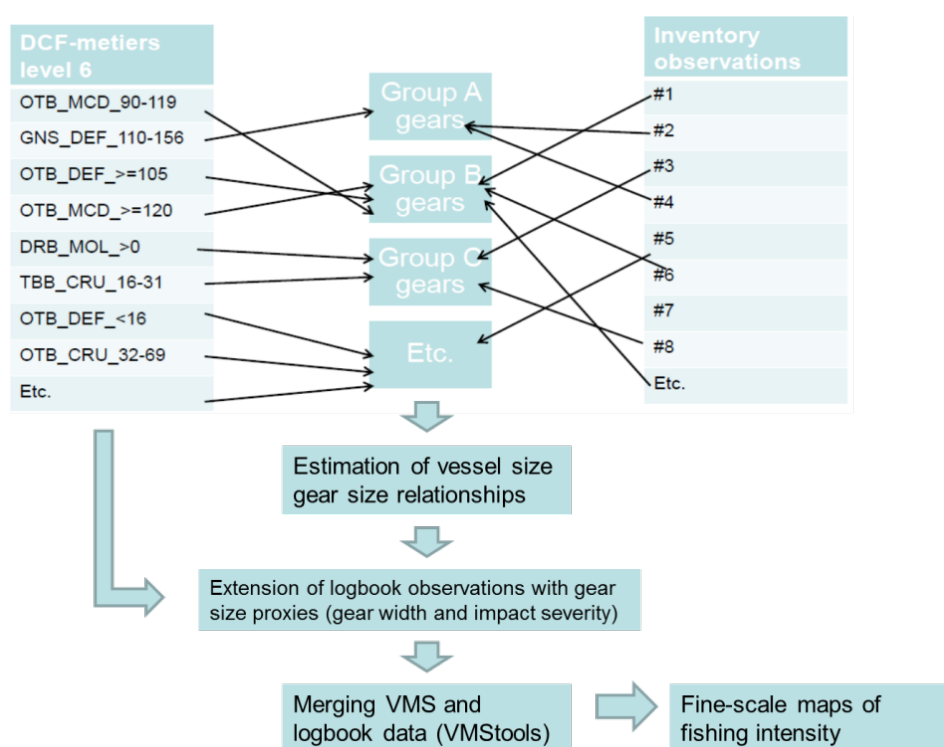
Figure 10.2. Diagram of BENTHIS framework for estimating fishing pressure from logbooks, VMS data and vessel-gear size information from industry survey.

Table 10.1. Number of vessel-gear observations obtained from industry sources, provided by Benthis partners.

	Observations collected			
	OT	TBB	DS	DRB
DTU Aqua	60	2	15	
IMARES	5	17	1	
ILVO		29		
CFRI	21	22		
CNR	508			
IMR				
MI	27			
CEFAS				
SLU	120			
IFREMER	55			
Marine Lab	270			
HCMR				
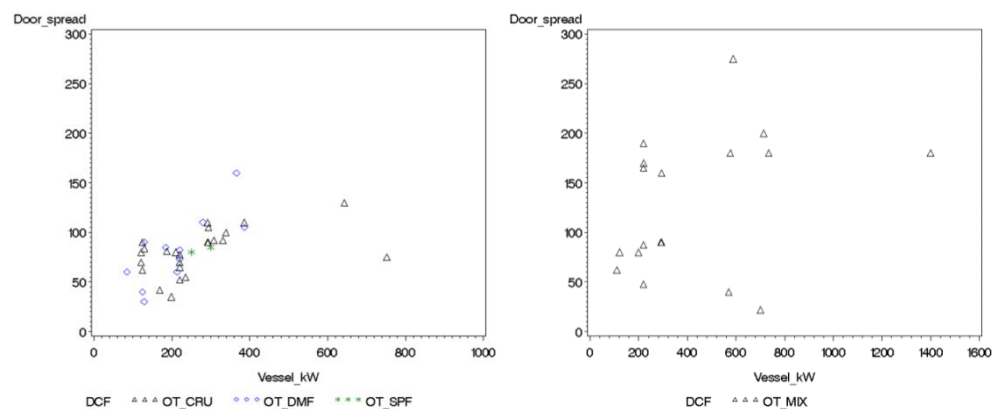
Figure 10.3. Door Spread against vessel kW by métier (OT=Otter board trawls, CRU=crustaceans, DMF=demersal fish, SPF=small pelagic fish and MIX=mixed crustaceans and demersal fish).
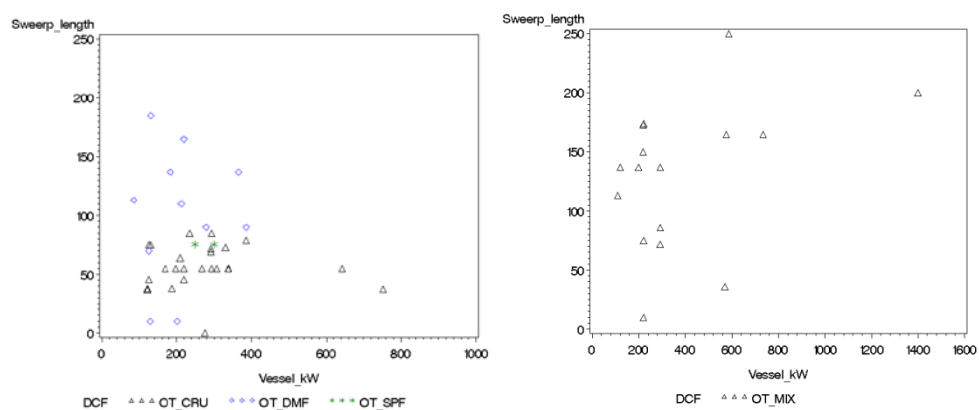
Figure 10.4. Sweep length against vessel kW by métier (OT=Otter board trawls, CRU=crustaceans, DMF=demersal fish, MIX=mixed crustaceans and demersal fish, SPF=small pelagic fish).
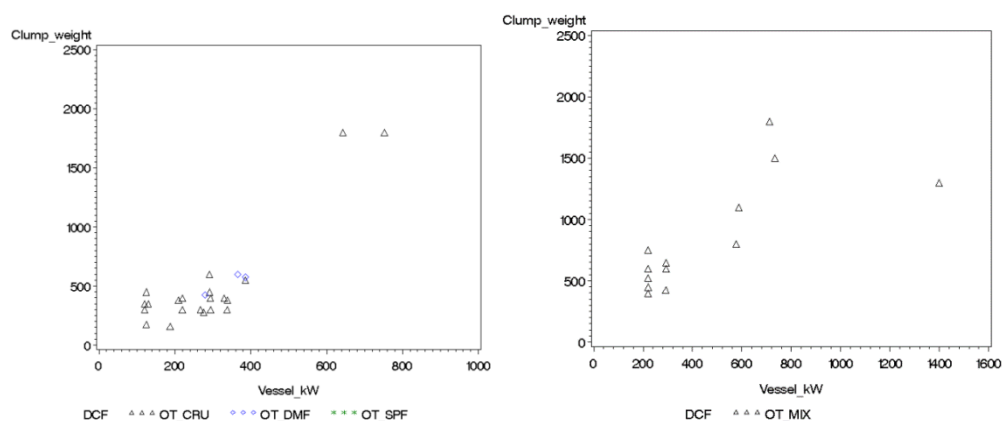
Figure 10.5. Twin trawl clump weight against vessel kW by métier (OT=Otter board trawls, CRU=crustaceans, DMF=demersal fish, MIX=mixed crustaceans and demersal fish, SPF=small pelagic fish).
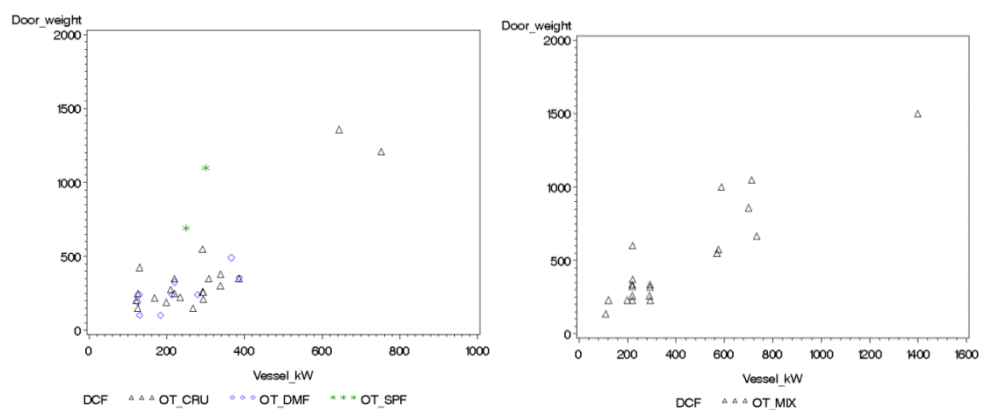
Figure 10.6. Otterboard (door) weight against vessel kW by métier (OT=Otter board trawls, CRU=crustaceans, DMF=demersal fish, MIX=mixed crustaceans and demersal fish, SPF=small pelagic fish).
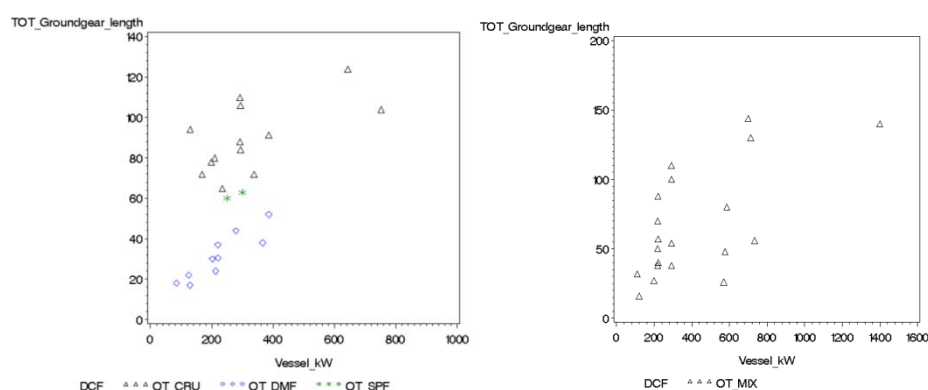
Figure 10.7. Groundgear length against vessel kW by métier (OT=Otter board trawls, CRU=crustaceans, DMF=demersal fish, SPF=small pelagic fish and MIX=mixed crustaceans and demersal fish).

10.4.2 MyGears framework for assessing Technical specifications of Mediterranean trawl gears

Council Regulation (EC) Nr. 1967/2006, concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean, establishes that technical specifications limiting the maximum dimensions of floatline, footrope, circumference or perimeter of trawlnets along with the maximum number of nets in multi-rig trawlnets shall have been adopted in accordance with regulatory procedure. Establishing the maximum dimension and number of fishing gears per vessel represents a way to control and limit the fishing effort.

The project MyGears (Figure 10.1) has systematically collected information through surveys on relevant initiatives of professional associations and specialized consultants, as well as on existing literature and data, including technical national and European reports, college and PhD theses, popular articles, conference and meeting proceedings, papers produced by non-governmental organizations and other forms of non-scientific literature. Information collected has been used in view of establishing synergies among different scientific domains while avoiding duplications. The study investigated the relationship between vessel- (LOA, towing force, engine power) and trawl-metrics to help refine fishing capacity definition by considering the fishing gear deployed. The first objective was the information collection on the characteristics of trawlnets used in different Mediterranean fisheries, with a view to identify the rigging and the maximum dimensions of trawl fishing gears in the Mediterranean EU Member State and acceding country (i.e. Croatia), Turkey and Cyprus. Specifically, we improved the technical knowledge of trawl gears and vessels specifications by addressing the following items:

- Definition and identification, suitable for enforcement and control purposes, of the maximum and minimum dimension of floatline, footrope, circumference or perimeter at various levels of the trawlnets;
- Nominal minimum/maximum linear dimensions and number of meshes in the front end and/or posterior transversal cross sections of both the trawl body, extension piece and codend *sensu-stricto*;
- Identification of otterboard size (width, height, projected area and weight), material, and typology (oval, Vee, cambered, multi-foil, vertical, etc.), along with the maximum/minimum number of nets in multi-rig trawlnets;
- Information on engine power, towing force, vessel design and technology including propulsion system;

- Nominal minimum/maximum longitudinal dimensions and number of meshes both in the codend *sensu-stricto* and extension piece. Relations between longitudinal and transversal dimensions at various levels of the trawlnets.

More precisely, in order to gather the information abovementioned, we have defined some main trawl typologies (e.g. pelagic, semi-pelagic, demersal-, bottom-trawl) corresponding to different target species groups, which basically represent different trawl fishing strategies in the Mediterranean. These strategies concern either swept volume or swept-area with respect to species that are either herded or not by various components of a trawl gear. Furthermore, different trawling technique (e.g. single-boat trawling, pair-boat trawling, multiple trawling) have been defined in order to homogenize information collection and to rationalize the field direct measurements. As second objective, myGears specifically investigated the link between vessel capacity and the size of the gear deployed. In order to analyse the influence of trawl type and trawling technique on the relationship between vessel, door and trawl size, linear mixed modelling (Pinheiro *et al.*, 2013) have been applied.

Based on the literature review carried out, five main trawl typologies have been recognized: pelagic 4-panel trawls (PTM4), demersal/bottom 2-panel trawls (OTB2), demersal/bottom 4-panel trawls (OTB4), semi-pelagic 2-panel trawls (OTM2) and semi-pelagic 4-panel trawls (OTM4). It was also noted that data from grey literature were more detailed and useful for the project purposes, than peer-reviewed papers. Literature review allowed the definition of a list of gear and vessel metrics, and develop an interview layout for the collection of new data. The layout was organized in three main parts: vessel and harbour data, otterboard data and rigging and trawl data. All the information collected were stored into an existing "ad-hoc technical database" developed at CNR-ISMAR of Ancona in 2006 during the EU-FP6-Project DEGREE (*Development of Fishing Gears with Reduced Effects on the Environment*). The technical database was further implemented and customized to suit the MyGears project needs. Based on the data and information gathered, the main technical indicators and metrics have been evaluated. To statistically analyse the relationships among different parts of the fishing gears /otterboard dimension / and vessel metrics, a mixed linear modelling approach have been applied.

Information on the technical aspects of the gear types used in the Mediterranean countries has been collected according to a standard format developed at the beginning of the project. Common rules for the measurement of gear parameters have been set in order to standardize the data collection.

The information on fishing gears have been stratified by **trawling technique** and **gear typology** on the basis of the available information obtained by interviewing some Mediterranean netmakers and door manufacturers. This approach has also facilitated and rationalized first the field direct measurements and second the further development of the models/calculations in the existing technical database and all the other succeeding relationships among different parts of the fishing gears as well as between some of these parts and the otterboard size and the vessel metrics.

The **single trawl technique**, commonly used to target demersal species, which are herded by the doors and the sweeps and bridle, is the most widespread demersal trawling technique. In such fisheries, the door spread and wingend opening are important parameters affecting catchability, but also vertical opening can be important for demersal fish species that have been shown to exhibit upward escapement behaviour when approaching the mouth of the trawl e.g. European hake, and red mullet. Single

trawls are also used for shrimp and French pelagic trawling, where focus can be made on both horizontal and vertical opening of the trawl, depending on the fishing situation and the target species (Sainsbury, 1996).

The main benefit from using the **twin trawl technique** is the ability to increase the horizontal opening at the wingends of the trawl deployed without proportionally enlarging the main body of the trawl, in which case the drag resistance would inconveniently increase. This is done by deploying two juxtaposed smaller trawls rather than a larger single trawl with increased horizontal opening. In other words, twin trawls enable to increase wingend spread (by approximately one third) without also increasing vertical opening and towing resistance (Sainsbury, 1996; Sala *et al.*, 2009a). This exercise is most useful in trawl fisheries targeting species closely associated to the bottom, which are not necessarily herded by the sweeps and due to their sedentary behaviour are not liable to escape over the headline of the trawl. Species such as Nephrops and monkfish fall into this category (Sangster and Breen, 1989) and shrimp trawls are also often fished as twin-rigs by Danish, Norwegian, Icelandic, Canadian and recently also by Southern Italian Adriatic fishers (Eigaard *et al.*, 2011; Sainsbury, 1996; Sala *et al.*, 2009a).

The **pair trawling technique**, where one trawl is towed between two vessels, is used primarily to increase swept-area and, by design, catchability compared to single trawling under certain conditions. This is the case when targeting dense shoals of pelagic species (e.g. anchovies and sardine). Fuel savings are also achievable as a result of avoiding the drag resistance from the doors, if any increase in net size when pair trawling does not counter the benefits of door removal (Buglioni *et al.*, 2006; Sala *et al.*, 2009b), as well as lower optimal trawling speed in some fisheries from improved herding of sweeps and trawl mouth when pair trawling. In pelagic operations, a single vessel directly in front of the trawl risks scaring the fish due to the wake of the vessel falling back directly into the mouth of the trawl, whereas in a pair trawl operation the boats can spread further apart and the fish can be herded back between the boats into the trawl. In some cases, the trawl deployed during pair trawling is up scaled to match the combined engine power of the two vessels. This is particularly attractive for smaller vessels.

Based on Eigaard *et al.* (2011) and personal communications with Mediterranean netmakers as well as knowledge of how trawl geometry, in Mediterranean **five conceptual trawl typologies** have been defined as follows. Each inventory observation will be assigned to one of the five trawl typologies according to the nominated target species:

1. **Demersal/bottom 2-panel trawls (OTB2)**. They tend to have long sweeps and bridles with large wingend spread and low vertical opening (1–2 m). Typical Italian OTB2-trawls are the *"Tartana"* and *"Volantina"* or the Spanish *Cadenero, Huelvano, Minifalda*, etc. They are usually used to target mixed demersal species, such us European hake (*Merluccius merluccius*), red mullet (*Mullus barbatus*), whiting (*Merlangius merlangus*), poor cod (*Trisopterus minutus capelanus*), monkfish (*Lophius* spp.) and Nephrops (*Nephrops norvegicus*). They are commonly entirely made up of knotless PA-netting (Figure 10.8).

2. **Demersal/bottom 4-panel trawls (OTB4)**. OTB4 trawls are generally used to target crustaceans such as deep-water rose shrimp (*Parapenaeus longirostris*), deep-water red shrimp (*Aristaeomorpha foliacea*), and Nephrops (*Nephrops norvegicus*). All shrimp species are predominantly captured by a

process of filtration. These trawls are characterized by having two bridles of 10–15 m to increase the vertical opening, which can be of around 2–4 m. Typical OTB4 are the Italian *Americana* trawl; the Spanish *Cuadrado*, *Dos Bocas*, *Espada*, *Tangonero*, *Semitangonero*; and the French *Jumeaux*, *Filet a chains*. Manufactured mainly with knotted polyethylene netting, can have sometimes knotless polyamide netting in the lower panel (Figure 10.8).

3. **Pelagic 4-panel trawls (PTM4)**. They are designed to catch shoaling pelagic fish that are off the bottom, such as anchovies (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), mackerel (*Scomber scombrus*), and horse mackerel (*Trachurus trachurus*). PTM-trawls are generally large trawls (e.g. *"Volante"* in Italian), with a high vertical opening, constructed with very big meshes (600–3200 mm) or ropes in the forward part of the trawl that herd fish towards the centre of the body of the trawl constructed in much smaller mesh size (Figure 10.8).

4. **Semi-pelagic 2-panel trawls (OTM2)**. They are designed for the Tyrrhenian fisheries to catch demersal fish such as gilthead sea bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*), and silver scabbardfish (*Lepidopus caudatus*) which are generally close to the seabed but exhibit an upward migration. The volume swept by the relatively large meshes (120–1600 mm) is what determines the capture efficiency and OTM2-trawls are typically constructed for having a mean vertical opening around 3–4 m. This trawl typology has always a 4-cable rigging (Figure 10.8).

5. **Semi-pelagic 4-panel trawls (OTM4)**. As for the OTM2, they are designed for the Tyrrhenian fisheries to catch demersal fish. Compared to the OTM2 it has a higher vertical net opening and is more efficient for the catching pelagic species. OTM4-trawls are designed for having a mean vertical opening around 4–10 m. This trawl typology has always a 4-cable rigging (Figure 10.8).

For the purpose of the current project and following the definition of 'trawlnets' applied in the EC Reg. 1967/2006, besides the abovementioned five trawl typologies, another gear typology named **Mediterranean bottom beam trawl typology** (**TBB**) has been defined.

"Trawlnets means nets which are actively towed by the main boat engine and consisting of a cone- or pyramid-shaped body (as trawl body) closed at the back by a codend and which can extend at the opening by the wings or can be mounted on a rigid frame. Horizontal opening is either obtained by otterboards or provided by a beam or frame of variable shape and size. Such nets can be towed either on the bottom (bottom trawlnet) or in midwater (pelagic trawlnet)".

In Mediterranean, there are different types of beam trawls, which are generally used in shallow waters. Some of these beam trawls operate more like dredges and often at national level, they are considered so. The most common examples are the Provençal (from the Southeast of France) *"Gangui"*, the Catalan (NW Spain) *"Ganguils"*, the Greek *"Kankava"* for sponges, the Italian *"Rapido"* trawl for the sole and the Sicilian *"Gangamo"* for prawns and sea urchins or the Sardinian *"Ganghero"* for mixed fisheries.
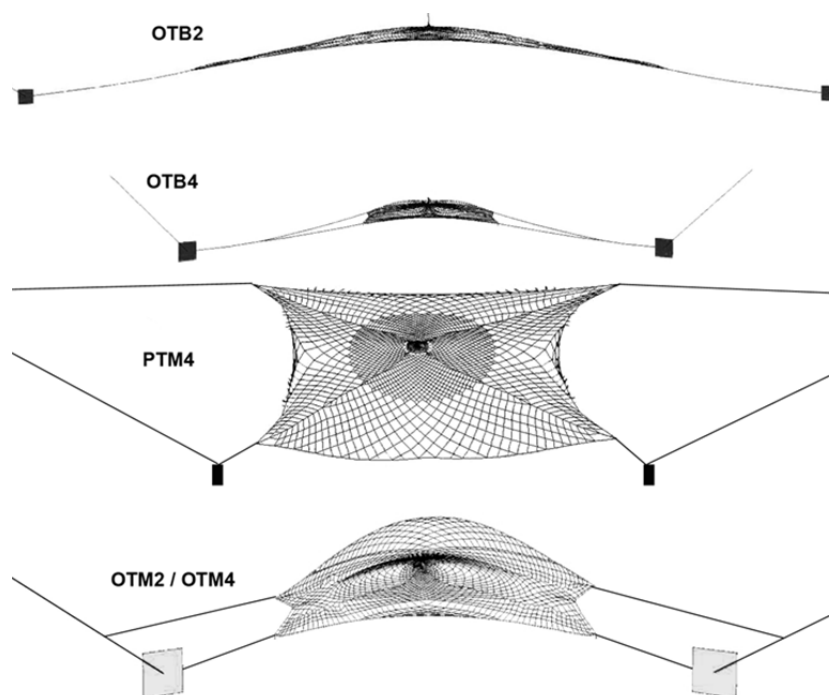
Figure 10.8. The five trawl types defined: Demersal/bottom 2-panel trawls (OTB2), Demersal/bottom 4-panel trawls (OTB4), Pelagic 4-panel trawls (PTM4), Semi-pelagic 2-panel trawls (OTM2), Semi-pelagic 4-panel trawls (OTM4).

The four Mediterranean countries investigated (e.g. Italy, Spain, France, Greece) have been divided in several regional areas on the basis of the characteristics of the fishing gears utilized by the fleet (Figure 10.9). In Spain, it was possible to distinguish four regional areas: 1) Catalonia, 2) Baleares, 3) Levante, 4) Andalucía and Alboran. In Italy, five specific areas can be defined: 1) Ligurian, 2) Tyrrhenian, 3) Sicilian, 4) Northern and Central Adriatic, 5) Southern Adriatic and Western Ionian. The Northern and Central Adriatic area is shared with the Croatian fisheries. In Greece, there is not any clear gears localization or characteristic trawl typologies by area. All the Greek trawls, traditionally named τράτα (trawl in Greek), have been therefore classified by three geographic regions: 1) Eastern Ionian; 2) Western Aegean; 3) Levantine basin. The latter area is shared with the Turkish fisheries. In the current project, the first objective was the information collection on the characteristics of trawlnets used in different Mediterranean European fisheries, with a view to identify the rigging and the maximum dimensions of trawl fishing gears within each trawl typology by Mediterranean EU Member State, however information have been collected also for Croatia, Cyprus, Turkey and Tunisia fisheries.

Empirical relationships among different parts of the fishing trawl gears, such as headline, footrope, fishing circle, trawl length, as well as between some of these parts and the otterboard size and the vessel length overall have been investigated. MyGears report shows all the graphs with relationships analysed by trawl type and country. The statistical analyses have been carried out based on the information collected in the four Mediterranean fishing fleets (e.g. Italy, Spain, France, Greece), both in the literature review and *in-situ* measurements. All the project goals have been achieved and an accurate investigation collecting all the requested technical specifications of trawl gears used in the different Mediterranean fisheries (benthic, demersal and pelagic) have been provided. The main findings can be summarized as follows:

- Technical specifications of the benthic, demersal and pelagic trawl gears in the main Mediterranean fisheries have been collected, specifically eight Mediterranean countries have been described: Italy, France, Spain, Greece, Cyprus, Croatia, Turkey, Tunisia;

- According to their technical features, Mediterranean trawlnets have been classified in six categories: Demersal/bottom 2-panel trawls (OTB2), Demersal/bottom 4-panel trawls (OTB4), Semi-pelagic 2-panel trawls (OTM2), Semi-pelagic 4-faces trawls (OTM4), Pelagic 4-faces trawls (PTM4), Mediterranean bottom beam trawls (TBB);

- Detailed technical trawl designs (technical net drawing) from 642 different trawlnets have been collected, specifically we found: 361 OTB2, 198 OTB4, 9 OTM2, 61 OTM4, 11 PTM4, 2 TBB, for the latter the Italian *Rapido* trawl can be considered the most representative beam trawl in the Mediterranean. We collected information on just two trawlers as its technical features are practically the same in all the Italian fisheries;

- All the information collected were stored into an existing "ad-hoc technical database" developed at CNR-ISMAR of Ancona in 2006 during the EU-FP6-Project DEGREE (*Development of Fishing Gears with Reduced Effects on the Environment*). The technical database was further implemented and customized to suit the myGears project needs. The database includes advanced calculation for the evaluation of gear performance and currently it can be considered as the most informative database for the Mediterranean trawl gears;

- To measure the dimensions of trawl gears, a wide range of metrics and indicators have been used, the main proxy metrics are floatline (or footrope, as they are practically highly related by a factor FL~0.95–0.98·HL depending on the trawl typology), fishing circle and square width, either with a single- or multi-rigging;

- Reliable models, which are able to establish a relationship between different parts of the fishing gear as well as between some of these parts and otterboard size and vessel characteristics, have been developed. These features have been discussed with fishing-nets makers and door manufacturers involved in the current study in order to evaluate their reliability and feasibility;

- The current results can be used as support to the management of trawl fisheries in the Mediterranean, specifically for the EC Reg. 1967/2006, Annex II where it is stated: "*Technical specifications limiting the maximum dimension of floatline, groundrope, circumference or perimeter of trawlnets along with the maximum number of nets in multi-rig trawlnets shall be adopted […]*";

- Despite the fact that relationships among gear metrics might vary accordingly to trawl typology, the main outcomes/findings related to the trawl dimensions can be itemized as follows (*note that measures have been rounded to the nearest integer number*):

1) Headline length (HL): min 12 m; max 128 m, mean 54 m;

2) Footrope length (FL): min 16 m, max 162 m, mean 69 m;

3) Trawl length (TrL): min 5 m, max 227 m, mean 66 m;

4) Square width (Wsq): min 12 m, max 188 m, mean 42 m;

5) Fishing Circle (FC): min 16 m, max 409.60 m, mean 75 m;

6) Codend Length (Hcod): min 1.5 m, max 28 m, mean 5 m;

7) Otterboard Length (OBL): min 0.92 m, max 3.37 m, mean 1.90 m;

8) Otterboard Height (OBH): min 0.50 m, max 1.90 m, mean 1.24 m;

9) Otterboard weight (OBW): min 68 kg, max 1350 kg, mean 450 kg.

- The codend length is a key element of the trawl design since it is the part of the net where most of the selection processes occur. Notwithstanding, in the Mediterranean Regulation any information have been provided as regards the length of codend. The overview drawn in the current report might certainly offer useful information in such regards;

- An overview about the riggings between the codend and extension in the Mediterranean has been provided. The direct *in-situ* measurements showed that all the diamond-mesh codends complied with the EC 1967/2006. Concerning the square-mesh codends, the EC Reg. 1967/2006 imposes a rigging within the range 0.25–0.50. Most of trawlnets investigated have been found between these limits;

- Information on the multi-riggings has been gathered. Specifically, we collected information on the Italian twin-trawls and French trawl *Jumeaux* where two nets are towed simultaneously by the same fishing vessel. Four trawls rigging have been found only in the Italian *Rapido* trawl fisheries;

- Information on the beam trawls has been collated. Some of these beam trawls operate more like dredges and often at national level, they are considered so. The most common examples are the Provençal (from the Southeast of France) *"Gangui"*, the Catalan (NW Spain) *"Ganguils"*, the Greek *"Kankava"* for sponges, the Italian *"Rapido"* for the sole and the Sicilian *"Gangamo"* for prawns and sea urchins or the *Sardinian "Ganghero"* for mixed fisheries. Only the *Rapido* trawl is considered as a trawlnet at a national level, therefore information on only this gear has been gathered;

- Beyond the project scope and the requirements of the European Commission, additional information on metrics and models have been collected and developed, such as:

1) Models between diameter and buoyancy in the floats;

2) Models between otterboard weight in-air and in-water;

3) Models among twine thickness parameters: diameter, *Rtex*, denier;

4) Overview and measurement of trawlnetting materials;

5) Models about hydrodynamic drag components;

6) Models about trawl gear dynamic parameters (horizontal door spread, horizontal net opening, vertical net opening, etc.);

7) Models on trawl design and calculations.
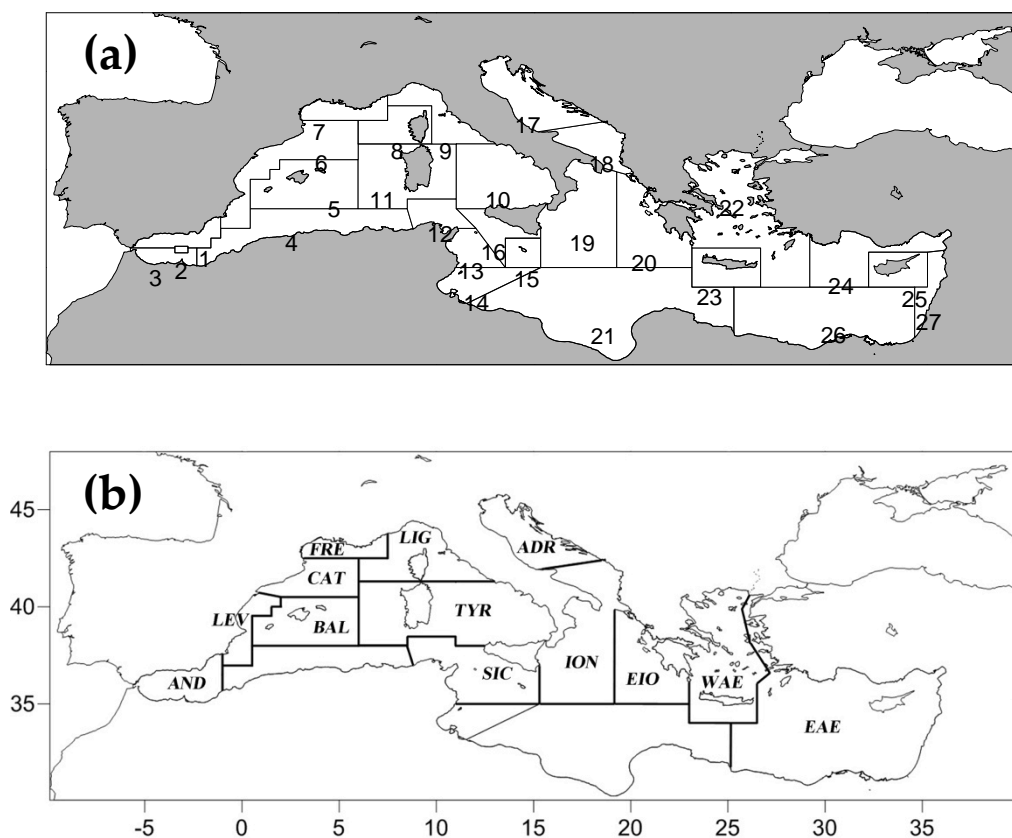
Figure 10.9. Mediterranean Geographical Sub-Areas (GSAs) in the GFCM area (a) as defined by the GFCM/33/2009/2 amending the Resolution GFCM/31/2007/2 and (b) Mediterranean regional areas classified by gear characteristics as defined in the current *myGears* project. Andalusia and Alboran (AND); Baleares (BAL); Catalunya (CAT); Levantine Basin (EAE); Eastern Ionian (EIO); French Mediterranean (FRE); Levante (LEV); Ligurian (LIG); North-Central Adriatic (ADR); Southern Adriatic and Western Ionian (ION); Sicilian (SIC); Tyrrhenian (TYR); Western Aegean (WAE).

11   ToR d): Technical Innovation in Spreading Trawls.

Conveners: Paul Winger, Bob van Marlen, and Antonello Sala

11.1 General overview

Mobile bottom trawls are known to produce ecological impacts in many fisheries. The devices used to spread these trawls (typically doors) contribute heavily to fuel consumption and seabed impacts. In response to these concerns, several countries have initiated research projects in recent years toward the development of creative and innovative approaches to spreading mobile trawls. Moving beyond basic doors and beams, new research efforts are now breaking ground toward off-bottom doors, manoeuvrable or steerable doors, kites, and hydrodynamic beam concepts. A synthesis of these technological advancements will provide up-to-date information, stimulating innovation and opportunities for technology transfer.

A topic group of experts was initiated in 2014 at the meeting in New Bedford, MA, USA. The goal was to document and evaluate recent technological advancements in spreading technology for mobile trawls. The terms of reference were:

i)   Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.

ii)   Review technical challenges and obstacles for uptake by industry.

iii)   Identify new applications for these technologies and opportunities for technology transfer.

At the meeting in New Bedford, a total of 23individuals participated in the Topic Group D (see section 2 below). A total of 10 presentations were delivered. Themes discussed included: design tools, semi-pelagic rigs, new innovative door designs, high tensile light material warps (Dyneema, Dynex), beam trawls and alternatives, semi-circle plate spreading groundgear, Gloria self-spreading pelagic trawl, use of kites as spreading devices, and alternative door riggings. This was graphically illustrated as:
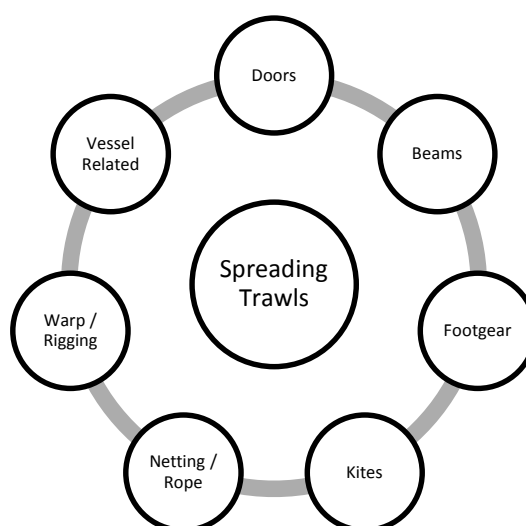
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11.3 Individual presentations

11.3.1 Beam trawl innovations

Bob van Marlen

Innovation is a major topic in the Dutch fishing industry, with many activities. An example is the Industry innovation day of 12/10/2012 providing opportunity for scientists, policy-makers, and the fishing industry to meet, discuss and networking. The coming EU Discard Ban starting 2016 for beam trawlers with major target species is an important driver for improving gear selectivity and quantifying and improving survival of undersized fish. Recently tried gear modifications were presented, such as a shorter beam trawlnet with the bosom made square, and with adjustments in the sole panel in front of groundrope. Another example is the release panel consisting of a codend split in upper and lower part with a small mesh panel in-between, and escape windows in the top section. These designs were shown to have potential in reducing the capture of undersized fish. Pulse trawls can also be used to bring discard levels down. Recently the number of licenses was increased to a total of 84 boats, of which some 20 new boats are fitted out at present. The method is strictly forbidden by European law (EC Reg 850/98, Art 31), but these vessels operate under derogation. Currently research into ecosystem effects of this gear is still carried out. A FishWing was tried out. It is a foil shaped beam. Towing tank tests showed a pressure drop on the suction side. A sea trial was done in 2013. Only 8 hauls could be made resulting in

lower catch and bycatch. The T-Line beam trawl consists of a system of pins scraping over the seabed, with lighter tickler chains, mounted in a square net. Further tests are planned in 2014. The HydroRig II is a beam trawl in which flatfish are stimulated to leave the seabed due to water flow manipulation. This new design features two wheels on each side replacing the conventional beam trawl shoes. It works with low towing speeds (~5 knots) and light tickler chains. The main target species is plaice. Tests will be done later in 2014. Another topic is the increased level of attention to fish welfare. A trial was made with electro-stunning to render fish unconscious before gutting then to be placed in icy water thus reducing suffering and obtaining and better meat quality.

11.3.2 Tools for door design and testing, Jumper project, Optimization and adjustment tools

Benoit Vincent

Aims: improve performance, and behaviour of doors. CFD tools are available, e.g. Fluent, Xfoil, Solid-works Flow simulation, OpenFoam, for 2D and 3D modelling, but give large uncertainties and different Cl, Cd and angle of maximum lift, and curve shape differs. Various examples of these differences were presented. Sometimes drag is underestimated. Are coefficients given by door makers reliable? How do flume tanks measurements differ from full-scale measurements at sea? Relative differences might be inferred. Need for a benchmark of these software products.

What is optimum door arrangement with 3 foils? 2D model used?

How to simulate door dynamics? Morison equation was used. Added mass and some damping should be taken into account. Output of DynamiT™ for different doors was presented. Effect of backstrop length was studied, and door behaviour during shooting.

Jumper door project, started in EU DEGREE, follow-up in national project with Morgère. Working principle of Jumper was explained. It takes longer to shoot this door. Jumper II with 3 foils. Fine tuning is needed to make it work. Theoretical tools can help.

Discussion

Difference by turbulence models (BO)? No, not a great effect. Wind tunnel tests in Italy with interesting results (AS). Semi-pelagic is OK, but bottom not. Three-foil was not more efficient (Q BvM).

11.3.3 Semi-demersal cod trawling in Barents Sea to reduce seabed contact

Melanie Underwood

Doors were raised, weights added on the footrope. Catches were not very different with doors off-bottom, but density was high and patchy, and visibility low. In the 2013 experiment this was not so. In high visibility and with noise of the doors the fish are more concentrated near the seabed. With doors on the seabed fish swam longer along with the trawl. Inside the trawl the behaviour is the same. Future: more observations of herding behaviour and bobbins on the sweeps.

Discussion

There are no consistent names for gear components and riggings (SE). Semi-demersal or semi-pelagic? Turbidity? Yes, the fleet was picking up the sediment. Could this have affected behaviour? Possibly. Anchor seining does not work at night in turbid water (TMP). Simrad door equipment was used to measure height and spread.

11.3.4 Innovative doors

Steve Eayrs

Trawling for prawns in North Australia. Doors are attached to the wingends. Headrope length 6–14 ftm. Aim: get maximum spread. When shooting away, the angle is 15–20 degrees; two doors are operated from the same derrick. On bottom the angle is 35–40 degrees. New Batwing door was designed to allow the two distinct operations shooting and towing, with much lower footprint. Less drag (-13%), turbulence and sediment disturbance (-90%), with more spread. A new batwing design was later made with a canvas sail instead of the foil, looking like a windsurf sail. Tests were done in a swimming pool and at sea.

Discussion

Why difference in load between headrope and footrope (UJH)? Because the design. Why not longer sweeps? Traditional design. But also there were no space between the two nets. Other applications: four trawls, two on each side with a sledge in the middle on each side.

11.3.5 Redesign of trawls and raised doors in demersal trawling

Ulrik Hansen.

Four projects on best available technology in four different fisheries were presented. Range of 200 - 800 hp vessels. Background: 40% of operating costs, and environmental issues concerning trawl gear. Small group formed and items to test identified: Dyneema warps, pelagic doors, twin-rig, dyneema trawl with nylon bands, 4 panel trawls for better control, T90 in codend for larger catches. Redesigned nets: huge trawls to compensate for reduced drag and catch more, side panels to manipulate trawl shape, flymeshes for larger spread, T90 in belly and reduce drag due to stickers, debris, etc.. Profitability could be raised with 48%, with 11 months payback time, for €52000 investment for the Baltic case, and 13% in gross earnings for the North Sea case, with €120000 investment. Doors contributed to 15% of the savings, with minimal shine after 12 months. Use nylon sheaves with Dyneema warps (no cover needed below 15 mm diameter). Can be wound on the drum without guiding mechanism.

Discussion

Dyneema 12 mm sample warp was shown to have worked for 10 years on a boat without problem. Does it affect warp/depth ratio? Not in our case, you may need more length. Use extra weight on the wires adding up to the replaced door weight. There are no selvedges (or riplines) in the Dyneema trawls, so that nylon bands can be used to absorb shock loads. Can Dyneema be spliced? Yes, even with a cover. Or tie a knot if they break. Beware of high temperatures with Dyneema warps; do not lead them over a chimney or exhaust!

11.3.6 How we spread the trawls in Iceland

Haraldur Einarsson.

Dynex, pelagic doors, Turbulance reduction. Dynex of Hampidjan mainly used in Iceland in mackerel fishery with 500–800 m warps and doors almost at the surface. Led core inside to sink it a little. Lifespan is 5–6 yrs. No downward force on the warps, full spread is achieved sooner. Not much used in bottom trawling. Doors rigged as V with pennants coming to one point, and not directly to the wingends. Patented X-stream

technology (metal rack with holes on the suction side). With semi pelagic doors fuel savings of 10–15% can be reached. Some went back in cod fishery to old doors (sound?). Remotely controllable trawl door (Poseidon). See: www.polardoors.com. Angle of middle foils can be altered independently in top part and lower part. Door spread went up from 68 to 72 m. Energy 550 kW to 450 kW down. Trawl can be moved sideways and down as well. Film on YouTube exists of Polar doors. Power needed to change angle is low and the system is battery operated.

Discussion

Why change door spread (UJH)? In West Africa, high currents occur and vessels are turning often, with doors heaved to the stern. This is not needed now (HE). Doors should be designed not to change door spread with speeds changes (UJH). Marine Laboratory Aberdeen tested doors with rotors in the 1970s-1980s, but they needed a power cable (BvM). Control can also be done with an acoustic system (AS).

11.3.7 Newfoundland beam trawl

Philip Walsh

There is a small coastal fleet of beam trawlers on the south coast of Newfoundland, Canada. The vessels are small (<45 feet) with poor economic viability. Issues with beam breakage have hindered efficiency. Beam length 50 ft was redesigned to 40 ft. A new net plan was also developed. Headline length reduced to 13.41 m. Three different types were tested, including welded aluminium, continuous aluminium, and carbon fibre composite beam. Warp tensions measured. Beams had buoyancy. Standard beam had more hook ups and less buoyancy. Carbon fibre was light and strong, but expensive to construct and difficult to repair. The continuous beam was the cheapest. All beams hooked up the seabed with no damage. Doors are not allowed in this small-scale fishery.

Discussion

Towing speeds are 1.7–1.8 knots (Q BvM). Catch rates were low (Q KB).

11.3.8 New wing trawling system for shrimp

Paul Winger and Kevin Brown

A short presentation was given on the Wing Trawling System developed by a harvester in Alabama, USA targeting shrimp in the Gulf of Mexico. See website here: http://wingtrawlingsystem.com/

Resembles the SumWing in the Netherlands to spread shrimp trawls.

Discussion

Also to be found on YouTube. Sort of airplane foil. With two flat shoes. Looks as a SumWing with a depressor in front, should costs €12000-€15000 for two pieces (KB).

11.3.9 Semi-circle plate spreading groundgear in Norway

Eduardo Grimaldo.

Pictures and video of flume tank work were shown, plates (PVC pipe split in two) bended outward to jump over stones. Can pass obstacles best. Then it was followed by full-scale experiments. Spread went up some 11%. Underwater observations were also

done in November 2013 and March 2014. This footrope passes easily over stones and boulders, and keeps fish from escaping underneath the footrope. It actually flies over the seabed most of the time. Previous plate gear was sensitive to rigging, but not in this new gear. Also lower drag and almost no sand cloud stirred up. Fishers liked the design. Low price; it is 1/3 of rock-hopper gear. Can be made in any size. No idea how it goes around a net drum. Would snap or crack if not strong enough. Same drag as the Rock-hopper gear. Keep all pipes, not just half? Maybe. Rubber? Might be too heavy.

11.3.10   Gloria Self–spreading pelagic trawl by Hampidjan

Haraldur Einarsson.

A short presentation was given about the concept and design by the netting manufacturer Hampidjan. It works quite well. It is sold as a high-speed trawl, and is easy to shoot and haul (HE).

Discussion

Idea compares to two strand rope, but some doubt whether it works that well. But it is a proven technique and it worked in a model (UJH). Altering knot orientation is used in Australian fisheries (SE). Empirical data are lacking, but it is observed in the flume tank using a twin-rig (SE).

Kites are used in a Norwegian zooplankton sampling gear. Kites were used in a shrimp trawl in USA, and headline kites (Iceland, Africa, Faroes). Also used on a codend cover. UJH showed kites on side panels of bottom trawls to open trawls. TMP has a reference. Also kites on the wings in a SINTEF project (UJH). Japanese kites were also mentioned.

Warp and rigging.

Optimization of warp and leg lengths in France. French rig (BV). DEGREE project alternative rigging by BIM, with flume tank trials (BvM).

Vessel

Pair trawling and seining.

Action: collect updates and pdfs in a library. Do we need a separate room next year? Yes.

Characterize a list of innovations

PW made an Excel-sheet for putting things together. Doors, beams, warp/rigging, kites were mentioned as heading. Items were detailed with country involved.

11.4 Discussion

11.5 Main Outcomes

A suite of new technologies was presented to spread trawls, often of an innovative nature. This shows that with relatively cheap alterations, bottom contact and fuel use can be reduced substantially while maintaining gear openings and catchability. The example of the Dutch SumWing is illustrative. A very old and common design of a heavy cylindrical beam with two trawl shoes has been replaced in a substantial part of the fleet by this new spreader, with less bottom impact and a fuel reduction of 10–15%. Other examples are the French "Jumper door" with less bottom impact, the semi-demersal trawl in cod trawling in the Barents Sea, innovative light trawl doors in prawn

fisheries in North Australia, redesign of trawls raised doors and Dyneema warps and parts of nets in demersal trawling in Denmark, Dynex warps and controllable pelagic doors in Iceland, new designs of beam trawls in the Newfoundland shrimp fishery, a new Wing Trawling system for the shrimping industry in the US, semi-circular plates spreading groundgear in Norway, the Gloria Self-spreading pelagic trawl by Hampidjan of Iceland.

11.6 Recommendations

The group feels it made good progress toward objective 1 (see section 1 above) and recommended to continue this ToR next year and meet again as a Topic Group. Action items during the year include: a) encourage R&D efforts, and b) assemble literature (grey and peer-reviewed) for distribution and sharing.

12   National Reports

12.1 General Overview

Participants were asked prior to the meeting to prepare summaries of current and expected research related to the activities of the WG within their country. Thirteen National reports were produced: Canada, France, Germany, Iceland, Ireland, Italy, Japan, Netherlands, Norway, Portugal, Scotland, Sweden, and the United States. The full text of these reports is inserted below, by country. The rapporteur presented a summary of some of the major themes crossing nations during the meeting. A word cloud was produced from the full text of the National Reports as a means of concisely and simply summarizing the main areas of interest in the reporting countries (Figure 12.1). The word cloud displays words in font sizes proportional to their frequency within the text – the bigger the word, the more frequently it appeared in the reports. Not surprisingly, words such as "catch", "fishing", "fishery" and "selectivity" were common. Consistent with prior experience, "trawl" was the most common gear seen in the cloud.

Figure 12.1. Word cloud of the text of all national reports. Word size is proportional to its frequency.

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.

To provide a brief overview of the research being carried out the projects described in the National reports were classified as being related to (i) towed gears, (ii) static gears, (iii) fuel efficiency, (iv) behaviour and physiology, (v) seabed impact, (vi) survival studies, (vii) management, fishing strategies, outreach or (viii) modelling, analysis, instrument development. It is recognized that projects can belong to more than one classification and that the classification are not necessarily independent Figure 12.2 portrays the proportion of projects in each classification.

Projects related to towed gears predominate (~37%), with about half as many static gear projects reported (~ 19%). There were approximately equal proportions (~ 10%) of projects related to behaviour and physiology; seabed impact; management, fishing strategies and outreach; and modelling, analysis and instrument development.

Figure 12.2. The proportion of projects from the national reports allocated in each classification.

12.2 ITALY

12.2.1 CNR Institute of Marine Sciences (ISMAR), Ancona

Institute of Marine Sciences (ISMAR) – Fishing Technology Unit, Ancona

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Discatch

The aim of the project is to support the identification of viable solutions to address factors determining the catches of unwanted species and specimens in trawl fisheries with a view to reducing unwanted catches and eliminating discards. The main objectives of the present project are:

- to provide an overall assessment of the fishing fleet discarding behaviour and to identify the main reasons for discarding in Mediterranean continental shelf demersal and small pelagic trawl fisheries;
- to identify measures, including technical ones related to fishing gear characteristics, to mitigate or eliminate bycatches of unwanted species and measures to eliminate discarding based on existing or new measures.

The project covers the following three non-adjacent Mediterranean subregions, as identified by the FAO Statistical Divisions, within the Western, Central and Eastern Mediterranean Basin where relevant demersal and small pelagic trawl fisheries occur.

eApulie

The aim of this project is the fuel consumption assessment referred to otter trawl fisheries in the South Adriatic by using a vessel monitoring system (VMS) conceived at CNR-ISMAR Ancona (Italy). The VMS consists of two mass flow sensors, one multichannel recorder and one GPS data logger. Data collected from such VMS will be analysed to assess a baseline in terms of fuel consumption for the local otter trawl fishing fleet, in order to evaluate possible future improvements. The project concerns also the introduction of some modifications in the fishing gears in order to increase energy efficiency of such fishery. Fishing gears of the vessels monitored will be equipped with trawl monitoring sensors in order to evaluate effective trawl geometrical configuration (horizontal net opening, door spread, vertical net opening etc.). Improvements on the fishing gears will be then introduced, starting by changing the otterboards, using pelagic doors instead of traditional otterboards. Data recorded by fuel and fishing gear-monitoring systems will be transferred to a remote server by GPRS, allowing an immediate access to data stored and allowing for an instant analysis of the trawl gear operating conditions. All the instrumentation will be installed onboard three bottom trawlers with different length and power, working in the Puglie Region, in Monopoli, Brindisi and Molfetta harbours.

Force

FORCE "Fishing and aquaculture-Oriented Research Capacity in Egypt" project is designed to enhance the capacity of the Egyptian National Institute of Oceanography and Fisheries, NIOF to carry out research activities aimed at supporting the implementation of sound and science-based policies for the sustainable development of fishery and aquaculture in Egypt, as well as in the whole Mediterranean North African region. FORCE will enable NIOF to fill the Scientific and Technological gap, which, at present, is one of the main factors that hampers the further sustainable management of fishery and aquaculture. The overall FORCE scientific objectives are to identify potential for more efficient cooperation between EU research institutions and NIOF focused on fishery and aquaculture as means of development of S&T and increasing sustainable yields; to support NIOF in developing a "tool-box" for environmental impact assessment of aquaculture activities; to disseminate the best practices and to raise awareness among scientists, fishery inspectors and policy-makers. In support of reaching competent sustainable management of fisheries, FORCE will promote the principles and objectives outlined in Horizon 2020 frameworks and EU Marine Strategies. FORCE will enhance the participation of Egypt in the FP7 by giving to NIOF the opportunity to coordinate a FP7 project.

Benthis:

BENTHIS (Benthic ecosystem fisheries Impact Study) is a five years project, aiming at integrating the role of marine benthic ecosystems in fisheries management. The European Union has funded the Benthis project to provide the urgently needed knowledge to support an integrated approach to the management of human activities in the marine environment, in particular fishing. Main objectives of the project are:

- The assessment of different marine benthic ecosystems status;
- The development of tools to assess effects of bottom trawling on the structure and functioning of EU benthic ecosystems;

- Development and testing, in close collaboration with fishing industries, of innovative technologies that reduce the impact of trawl fisheries on the benthic ecosystem;

- Development of sustainable management plan in order to reduce the impact of fishing and quantify its ecological and socio-economic consequences, together with the fishing industry and other stakeholders on a regional scale.

Project activities are organized in many case studies (Baltic sea, North sea, Western waters, Mediterranean sea, Black sea), in close collaboration with industry and stakeholders through regional meetings and other events.

Stock Assessment of the striped venus (*Chamelea gallina*) along Western Adriatic coast:

Chamelea gallina (Linnaeus, 1758) is an infaunal clam of the Veneridae family (Bivalvia: Lamellibranchiata: Veneridae), locally known as 'vongola' or 'lupino'. It lives buried within fine well-sorted sands (0–12 m depth) where it is so abundant and dominant as to constitute a 'facies à C. gallina'. Annual surveys aimed at analysing and quantifying the Chamelea gallina population in the Maritime Districts of Ancona and San Benedetto del Tronto (Italy) were carried out in 2012 by ISMAR – CNR Ancona as part of stock assessment programme of the complete western Adriatic stock with the aim of providing scientific data for management. Furthermore, a selectivity study has been provided in order to evaluate the selectivity rate of actual hydraulic dredges operating in the Adriatic. A selectivity time saving protocol has been assessed and the size measurements has been carried out using photo analysis which allows an automatic and fast size measurement. Results achieved during 2012 will be compared with those will be obtained during 2013.

EcoFishMan

EcoFishMan is a three years multidisciplinary project, involving scientists and stakeholders in activities relating to biology, stock assessment, technology, economy, sociology and legal aspects of fisheries management. The new system will be based on responsiveness, flexibility, stakeholders' responsibility and communication. Fishers will provide scientists and authorities with more data than before, using already available instruments such as electronic logbooks. This will allow for rapid response to changes in the environment and increased communication between stakeholders. The burden of proof that the fisheries are ecologically sustainable will be shifted towards the fishers. With more data exchange, a more focused management of the value chain of fish will be possible and thereby the economical and social outcome of the fisheries improved.

ICEEF 2013

This project is part of the work programme for action FISHREG. JRC has already developed a pilot website on energy efficiency in fisheries that is available online at https://energyefficiency-fisheries.jrc.ec.europa.eu/. The site is accessible directly through the Europa website of DG MARE for fisheries. The pilot website includes reference documents and studies related to energy savings in fisheries, general information on research and funding opportunities and links to relevant EU projects, EU legislation and events, among others. The information collection is organized in many topics. Each topic reports the state-of-the-art as well as innovations which allow to achieve a sensible fuel saving. The website reports also information about the most

important event related to fisheries and energy saving thus representing an interesting opportunity to spread and collect information on energy efficiency for fisheries. The most important result for this website is to become a hub of information to connect scientists, stakeholders and fishers altogether.

Droptek

An innovative magnetic device for the reduction of fuel consumption and pollutant emissions has been installed onboard an Italian bottom trawler since March 2013. Through this device, a magnetic treatment is applied to the incoming fuel in order to increase the air/fuel mixing process. The consequence of treating fuel with a high magnetic field is supposed to improve combustion of fuel and consequently increasing engine power as well as reducing fuel consumption. The bottom trawler is equipped with a fuel consumption measurement system conceived at CNR-ISMAR of Ancona since 2008. The historical series of data collected allows a comparative approach to assess the impact of the magnetic device on the fuel usage. Preliminary evaluation on fuel usage demonstrated a fuel consumption reduction of about 5%. Further analyses are necessary in order to better understand the relationship between fuel flow and magnetic field.

BYCATCH V

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

MARTE+

The project provides for the establishment of a Scientific-Technical Working Group, composed of persons representing the four regions of the border area (Corsica, Liguria, Tuscany and Sardinia), with the following duties:

- Analysis of fishing systems in use nell'areale border to assess the positive and critical;
- Setup of specific experiments of systems/gears innovative sustainable and take into account the requirements and regulations regarding the needs of the regions involved in terms of traditional fishing activities of fishing communities, socio-cultural and environmental. In particular, this project claims to proceed with testing of nets for a catch of some species of commercial interest, including the testing of technical equipment available to enhance the selectivity, used mainly in the small coastal fishing. Based on past experiments based on comparison among traditional local fishing gears and pots, during 2013 and 2014 sea trials are in progress for tests with new "purse-seine-based" fishing gear without a purse line in order to compare traditional local and new fishing gears.

Tartalife+

TartaLife project aims at reducing sea turtle mortality by reducing bycatch caused by pelagic longline, bottom trawl and fixed nets, disseminating circle hooks and TEDs (Turtle Excluder Devices) and testing STARs (Sea Turtle Acoustic Deterrent) and a new type of pot. The second goal is to reduce post-capture mortality, by training fishers and strengthening the Marine turtles First Aid/Rescue Centres. The project is financed with the contribution of the LIFE+ 2012 financial instrument of the European Community and co-financed by the Italian Ministry of agricultural, food and forestry policies and Marche Region. In line with the UNEP RAC/SPA's MAP (2001) and the National Action Plan on Marine Turtles which the Italian Ministry of Environment is currently drafting, the project TARTALIFE+, involving all 15 Italian regions overlooking the Mediterranean Sea, aims at reducing the mortality of Caretta caretta and thus contributing to the conservation of the species in the Mediterranean, via 2 specific objectives:

- Reducing bycatch caused by pelagic longline, bottom trawl and fixed nets disseminating circle hooks and TEDs and testing STARs and a new type of pot.
- Reducing post-capture mortality, training fishers and strengthening the Marine turtles First Aid/Rescue Centres.

The project is organized in different actions:

- Dissemination of circular hooks in pelagic longline fishing;
- Update and dissemination of TEDs Turtles Excluder Devices in bottom trawl fishing;
- Testing of new acoustic deterrent for marine turtles STAR Sea Turtles Acoustic Repellent and of a new type of pot;
- Training of fishers on how to rescue and deliver first aid to accidentally caught turtles;
- Strengthening Marine Turtles Rescue Centres (equipment and re-training of staff), setting up a Centre in Lampedusa and first aid points on Emilia Romagna and Marche coasts;
- Setting up information desk and technical assistance contact point to support fishers in requesting funds for the replacement of traditional fishing gears with low-impact ones;
- Monitoring of conservation actions, including socio-economic impact of the project;
- Communication and dissemination actions, such as: info days for fishers, website, raising awareness campaign for tourists, local populations and schools, information material, layman's report, etc.;
- Project management and monitoring and networking activities.

More info at www.tartalife.eu

Efficientship

The EfficientShip project will demonstrate the efficiency of an innovative technology for reducing the GHG emissions of thermal engines - for power rates from 300kW to 2MW - by 5–10%. The interest in ORC is growing for the past few years, with different

applications in heavy industries or biomass production centres, working with power rates of several decades of MW.

The project challenges are:

1) To adapt an innovative heat recovery technology (ORC) to mobile thermal engines, allowing the reduction of between 5 to 10% of the GHG emissions.

2) To raise awareness of the European fishing sector on the importance of the reduction of the vessels GHG emissions in a context of global warming and to offer them some simulation on the adaptation of the EfficientShip innovation on their vessels.

The EfficientShip project will develop and demonstrate the efficiency of an ORC module adapted to one fishing vessel operating in Irish coastal waters. To reach its objectives the project will include:

1) A preliminary analysis of the specificities of the demonstration vessel and the operating conditions will be realized by ENOGIA and IFPEN in order to depict and adapt a reliable ORC module. The performances of the vessel will initially be assessed by CNR to constitute a baseline for analysing the demonstration results. Moreover, a simulation of the expected performances will be realized to be further compared with the effective achievements.

2) Once depicted, the prototype will be constructed and validated before its installation (B1). Partners will then install it on the demonstration boat, with all the necessary monitoring equipment. A demonstration phase of seven months will then occur, during which the vessel will run its traditional fishing activities. Vessel's crew (KFO) will be in charge of the maintenance of the module and the data collection, following a standard procedure established by CNR.

3) The regular data collection will allow CNR to produce a complete evaluation of the demonstration phase regarding environmental, technical and economic performances and to compare it to the baseline data. The assessment of the effective results will allow validation or adjustment of the module specifications and the simulation algorithm developed in action A1. This tool will then be used to produce a matrix with the expected impact of the ORC technology on typical EU vessels and operating conditions. These data will then be used for exploiting the project solution on the European scale, following the exploitation plan terms.

4) The participation of several experts in an Advisory Board with complementary expertise (other engine's types or sizes, policy-makers etc.) will enlarge the potential applications of the EfficientShip solution.

5) To support the development of these actions and ensure a wide diffusion of the EfficientShip project outputs, an ambitious dissemination plan has been designed. The dedicated website as well as promotional material coupled with the implication of several influent stakeholders in an Advisory Board will guarantee a large diffusion of the project.

Maremed

The project investigated on Transferable Fishing Concessions (TFC), including an introductory analysis of the legal framework and state-of-the-art at the European level, and an evaluation of the appropriateness, transferability and modes of applicability of

a fisheries management model based on a TFC system in the Mediterranean area, which is characterized by multispecific, multigear and small-scale fisheries. In September 2007, the European Parliament carried out a workshop on fishery Rights-Based Management (RBM) in fisheries, aimed at outlining further developments of the CFP legal framework. Conclusions and recommendations of the RBM workshop carried out by the European Parliament suggested to consider the introduction of a system based on effort regulation. This is particularly relevant to multispecies, multigear fisheries, such as Mediterranean ones, where RBM is more likely to be effective if it is related to the set up of Individual Transferable Effort (ITE) systems.

Transferable Fishing Concessions (TFC) are defined in the proposal (EU COM, 2011b) as "revocable user entitlements to a specific part of fishing opportunities allocated to a Member State or established in management plans adopted by a Member State in accordance with Article 19 of Regulation (EC) No 1967/2006, which the holder may transfer to other eligible holders of such transferable fishing concessions".

The main goals of this pilot action were:

- To increase knowledge and competences on TFC in view of the next European Maritime and Fisheries Fund (EMFF), which will enter into force on 1 January 2014 until 31 December 2020;
- To assess the appropriateness and transferability of a fisheries management model based on a TFC system to the Mediterranean context, also outlining specific modes of applicability.

Driftmed

Small driftnets of limited length and relatively small mesh size to catch small/medium sized species have been used for generations by many artisanal fleets along the Mediterranean coasts, without major environmental concerns. Problems started in the late 70s-80s when the use of driftnets with larger meshes and much greater overall size targeting mainly swordfish and tunas rapidly expanded outside any preventive control. These type of nets led to large incidences of unwanted catch and created a great environmental concern.

In this context, the MAREA Specific Contract n.8 ("Identification and characterization of the small-scale driftnets fisheries in Mediterranean" acronym DRIFTMED) was carried out, with the main objective to identify and characterize, both for the past and the present, the small-scale driftnet fisheries (SSD fisheries, e.g. those using nets < 2.5 km in length and not targeting species in the Annex VIII) in the Mediterranean. Other specific objectives were:

- Provide technical information on the driftnet gear (mesh size, twine thickness, rigging ratio, etc.);
- Identify and describe SSD fisheries currently used by countries other than EU Member States in Mediterranean Sea;
- Identify and describe alternative fishing methods to catch the same species or group of species exploited by the small-scale driftnets;
- Provide information on the economic parameters pertaining to each EU Mediterranean small-scale driftnet fishery;
- Provide an overview of the international/EU/national provisions regulating the use of driftnets fisheries in Mediterranean Sea.

DRIFTMED had also the objective of providing update outcomes to the Commission service and of guaranteeing the coordination and interaction with the Specific Contract n.5 (SC5) MARE/2011/01 "Study in support of the review of the EU regime on the small-scale driftnet fisheries". DRIFTMED and SC5 were in continuous contact, sharing data and information. DRIFTMED was structured into four inter-correlated Work Packages and included three main activities:

- The review of all the existing available information;
- The collection of new data regarding the technical characteristics of the gears, as well as the cpue and catch composition;
- The analysis of the gathered data to identify and characterize the currently active SSD fisheries, in terms of fishing capacity/activity, composition of the catches, socio-economic relevance.

12.3 GERMANY

12.3.1 Thünen-Insitute for Baltic Sea Fisheries (TI-OF)

Development and testing of FRESWIND, a new flatfish bycatch reduction device in Baltic Sea cod-directed trawl fishery

Contact persons: Juan Santos (juan.santos@ti.bund.de); Bernd Mieske (bernd.mieske@ti.bund.de)

Flatfish discard rates in Baltic Sea are high even though the implementation of selective cod-oriented codends in commercial fisheries. The FRESWIND is a new selection device originally proposed by the industry to reduce flatfish catches without loss of commercial cod catches. Three research cruises and one commercial trip were used in order to develop the original idea into an optimized design, both in terms of efficiency and practical implementation in commercial activities. The different FRESWIND specifications varied in windows orientation, window material, and presence/absence of guiding device. All the sea trials experiments were based on twin trawling setup, where the reference gear was a commercial specification using the mandatory Bacoma codend as selective device, while the test gear was similar but with the FRESWIND fitted ahead of the Bacoma codend. Length-dependent catch comparison analyses were carried out using standard procedures besides a new approach based on structural modelling. The analysis showed a significant flatfish catch reduction for the best FRESWND setup (up to ~68%). For the same specification, it was found up to ~32% undersized cod catch reduction in the test gear, while losses of marketable cod were minor (7%) and can be optimized by adjusting the grid bar spacing.

Testing stimulating techniques to improve fish contact likelihood to extension upper net panel (cruise: CLU275)

Contact person: Juan Santos (juan.santos@ti.bund.de)

During the last decades, an active research has been carried out to develop gear technologies to supplement codend selectivity. Among others, Square Mesh Panels (SMPs) fitted to the top panel ahead of the codend are one of the most tested alternatives, being in some cases introduced into European regional legislations. The SMP functioning relies on utilizing escape behaviour and assisting escape by maintaining an open mesh structure in a certain area of the gear. For these SMPs to work efficient it is required that a large fraction of fish do come into contact with the top panel of the gear at the

location of the SMP during capture process. For some species, this requirement might not be satisfied given the natural behaviour for many fish species to stay clear of the netting on their travel towards the codend. How to stimulate fish to contact a SMP fitted to the extension piece top panel was taken as Research Topic in October 2013 on board the German RV "CLUPEA". A number of positive-buoyancy ropes attached to the bottom panel below the SMP to force fish to alter their natural swimming behaviour upwards. The SMP mesh size netting was chosen sufficient big to allow all length classes to escape once they contacted, therefore the experimental setup also addressed potential interaction between fish length and contact likelihood.

Development and testing of innovative solutions in standard trawls to achieve bell–shaped size selection patterns for Baltic cod (cruise: SO687)

Contact: Daniel Stepputtis (daniel.stepputtis@ti.bund.de)

Recent research in fish biology has demonstrated that older individuals of several fish species including cod can have better reproductive efficiency than younger mature fish being key length classes for relevant stocks. These findings are not supported by the current strategy used to improve trawl selectivity, which aims at releasing small sized individuals and retaining larger ones, resulting in selection curves where the retention likelihood increases with fish size. However, when combining existing technologies for selection devices, it would be possible to develop gears with adopted size specific retention likelihood that also take into account the reproductive importance of large fish. A research cruise in German RV "SOLEA" recently addressed such Research Topic focused on Baltic cod as case of study. The data produced during the cruise demonstrated that it is possible to achieve a so-called 'bell-shaped' selectivity curves by means of technological modifications in the standard trawl, used in the Baltic cod-directed fishery.

Impact of codend mesh size and geometry on selectivity and retention in the brown shrimp (*Crangon crangon*) fishery

Contact person: project leader: Thomas Neudecker (Thomas.neudecker@ti.bund.de); experimental selectivity: Juan Santos (juan.santos@ti.bund.de), Daniel Stepputtis (daniel.stepputtis@ti.bund.de); FISHSELECT: Bente Limmer (bente.limmer@ti.bund.de), Bent Herrmann (bent.herrmann@sintef.no)

The brown shrimp fishery in the North Sea is an important economic factor in German coastal areas of Schleswig-Holstein and Lower Saxony, where approx. 200 vessels are involved. As for other fisheries, shrimp fishery is criticized for its temporarily large amount of discards of small shrimp and fish. This discussion is amplified since shrimping is often conducted in the Wadden Sea National Park. Consequently, it is agreed between stakeholders that discards in this fishery have to be reduced.

We conducted a codend selectivity study as part of an effort to establish a sustainable trawl fishery. 224 tows were completed in 2013 on four different research cruises with the German RV "Solea". Due to the availability of paired beam trawl rigging on board "Solea", the paired gear method was chosen as experimental design. The set of Test codends included three different mesh geometries (Standard mesh T0 / Turned mesh T90 and 'Square mesh' T45) and mesh openings ranging from 14 to 34mm. The control codend was an 11 mm diamond mesh codend, assumed non-selective over the relevant Crangon length-class population. Based on the results for individual tows, the theoretical selection potential of brown shrimp are analysed together with our Danish partner

Bent Hermann for the different mesh types and mesh openings, using the FISHSELECT method.

12.4 CANADA

12.4.1 Fisheries and Marine Institute of Memorial University of Newfoundland

Drop Chain Footgear:

This study compared the effectiveness of a low seabed impact footgear (i.e. dropper chain footgear) vs. a traditional rock-hopper footgear on identical inshore Vónin shrimp trawls. Results from flume tank testing demonstrated that the trawls were similar in net geometry but the experimental trawl had a 62% reduction in contact area compared to the control trawl. Comparative at- sea fishing trials revealed that the dropper chain footgear trawl has the potential to catch a similar amount of shrimp with appropriate dropper chain rigging and modifications. The experimental trawl had significantly lower resistance (i.e. warp tension) than the control trawl, however this did not translate into a detectable reduction in fuel consumption. Further trials are planned for 2014. Contact: PhD student Truong Nguyen (Truong.Nguyen@mi.mun.ca).

Evaluation of Different Beam Designs for the Northern Shrimp Beam Trawl Fishery:

Persistent problems exist with beam trawls used off the coast of Newfoundland and Labrador, Canada. The beams being used are continuously breaking or being damaged and when the beams are reduced in length (to prevent breakage), the catch rates attained are not economically sufficient for harvesters. This study investigated three different types of beams to gain insight into whether beam type plays a role in reducing damage. We compared a standard welded aluminium beam to two experimental designs (continuous aluminium and carbon fibre). Trawl tension, hookups, catch rates, material, and cost were compared for the different beams. Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).

Simulation vs. Flume Tank:

Few examples exist in which the accuracy and precision of numerical and physical modelling techniques have been compared to full-scale trawl performance at sea. A project is currently underway to statistically compare three datasets (numerical vs. physical vs. full-scale) for the Campelen 1800 survey trawl. We hope to discuss the merits/limitations of each approach and how each can assist the gear development cycle. Contact: PhD student Truong Nguyen (Truong.Nguyen@mi.mun.ca).

Semi-Pelagic Trawl Doors:

The objective of this project was to compare a traditional bottom-contact shrimp trawl (control) to that of a semi-pelagic trawling system (doors off bottom). Laboratory testing of scale models was conducted for both the control and experimental systems using the Marine Institute's flume tank. In the summer of 2013, comparative sea trials were conducted on board two commercial fishing vessels (parallel-haul) in NAFO Division 3L. Due to technical difficulties, only four tows out of 13 tows were considered to have the doors completely off the bottom. The catch rates and bycatch results from the preliminary assessment were encouraging. Additional sea trials are planned for 2014. Contact: Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Reducing Seabed Impacts of Bottom Trawls:

A five-year project is currently underway with Vónin Canada Ltd. to develop bottom trawl technology capable of catching commercial quantities of finfish and shellfish with reduced seabed contact compared to traditional systems, thereby reducing significant environmental impact on the seabed. The objectives of the project are to conduct computer simulation of innovative fishing systems; evaluate physical models using the flume tank; and construct and evaluate full-scale prototypes. Contact: Paul Winger (Paul.Winger@mi.mun.ca).

Twin-Trawling for Inshore Shrimp

A project was initiated with Hampidjan Canada Ltd. in 2013 to develop twin-trawling technology for the inshore shrimp fleet in Newfoundland and Labrador. A combination of numerical modelling and flume tank trials were conducted. Initial sea trials were carried out aboard the 68.5' (20.9 m) 850 Hp F/V Atlantic Charger in NAFO Division 3K. Contact: Harold DeLouche (Harold.DeLouche@mi.mun.ca).

Hake Potting:

A study was recently initiated to develop baited pots for white hake (*Urophycis tenuis*). Comparative fishing experiments using Newfoundland and Norwegian pots designs was conducted in autumn 2013 on the Southwestern edge of NAFO Division 3Ps and 3O, near the Laurentian Channel. Experiments were conducted onboard the 16.8m (55') F.V. Burin Tradition. Results showed that the Norwegian pot performed very well in catching white hake and crab species. The Newfoundland pot without triggers also performed well, but the research team speculates that this pot may perform even better if some minor modification were made to incorporate lighter materials with monofilament netting entrances. Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).

Greenland Shark Bycatch Reduction – Longline Modification:

A multiyear study has just been completed investigating the feasibility of longline modifications to reduce the bycatch of Greenland shark in Nunavut's (Canada) Cumberland Sound turbot fishery. The primary objective was to test the ability of 1) various gangion breaking strengths, 2) gangion length, and 3) the interval between gangions to reduce the capture and/or entanglement of Greenland shark in turbot longline gear without reducing the catch rates of turbot. Sea trials were conducted in 2011, 2012, and 2013. Contact: Scott Grant (Scott.Grant@mi.mun.ca).

Behaviour of Northern Stone Crab Using Deep-Water Video:

A field study is currently planned for autumn of 2014 to collect underwater still images and video of Northern stone crab (*Lithodes maja*) interacting with baited traps in situ off the south coast of Newfoundland in depths up to 800 m. We hope to identify design factors that hinder crab entry into traps, or promote escapement, so that traps can be modified to optimize crab catch. Quantitative analysis of the video is expected. Contact: Brett Favaro (Brett.Favaro@mi.mun.ca).

12.4.2 Fisheries and Oceans Canada – Central and Arctic Region

Greenland Shark and Arctic Skate Bycatch Reduction – Pot Traps

A multiyear experiment was initiated in 2010 to test alternative gears that could be used to reduce shark and skate bycatch in the Cumberland Sound Greenland halibut

fishery. Currently, the fishery exclusively uses bottom-set longlines and primarily catches Greenland Shark and Arctic skate as bycatch. In 2010, three pot traps based on the design of the Alaskan cod pot were built and tested in Cumberland Sound as a pilot project. In a limited number of sets, the pots caught Greenland halibut and did not catch either Greenland sharks or Arctic skates. In 2012, additional pot traps will be built and tested in a full experiment to assess differences in catch rates and the commercial viability between longlines and pot traps in the Cumberland Sound fishery. Contact: Kevin Hedges (Kevin.Hedges@dfo-mpo.gc.ca).

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

Controlling bait costs in Lobster and Snow Crab fisheries in Québec:

The main objective of this research program is to find some solutions to reduce the cost of bait in crustacean fishing pots fisheries. Secondary objectives are: 1) to increase our knowledge of traditional practices in different fishing areas in Québec; 2) to develop optimized bait using 25% less fish and alternative bait based on fish processing by-products and evaluate their effectiveness in terms of fishing yields; and 3) to involve the fishing industry in the innovation process and facilitate the technology transfer. Contact: Jean-François Laplante (jean-francois.laplante@merinov.ca).

Kite Sail on a Shrimp Trawler:

This project consists of installing a kite sail on a shrimp-fishing vessel to reduce the fuel consumption. The first step of this two-year project will be related only to the installation and the optimization of the kite system onboard. Launching and recovering operations and security tests will be performed. During the second year, comparative at-sea trials will be performed to quantify energy savings. In addition, navigational data (fuel consumption, RPM, boat speed, etc.) and environmental data (wind force and direction), will be recorded the entire fishing season. Specific care will be given to safety and security. Contact: Damien Grelon (damien.grelon@merinov.ca).

Codend development: enhancing filter efficiency and shrimp quality:

A project will be carried out in 2014 to compare traditional and experimental codends for shrimp trawls, using the twin-trawling approach. The goal is to reduce net drag and enhance shrimp selectivity. A combination of numerical modelling, flume tank trials, and at-sea demonstrations are planned. Contact: Damien Grelon (damien.grelon@merinov.ca).

Modification of Rock Crab Pots to Increase Selectivity:

Rock crab is harvested using conical pots that are not very selective and in some areas, a not-insignificant quantity of lobster ends up as bycatch. In 2012, a study was carried out to study the performance of a selecting device in rock crab pots. This one is made of a disk with two slots through which rock crabs can enter the cage but not commercial size lobster. The device is installed at the base of the entrance cone and is hinged. Thus, it is easy to add bait. The goal of the project was to assess the impact of the modification on on-board work time, compare the number of crabs caught in modified traps to catches using conventional traps, and compare the effect on bycatch. Contact: Damien Grelon (damien.grelon@merinov.ca).

Development and introduction of a lobster slide:

Female lobsters with eggs need more precaution when they are thrown overboard. Loss of eggs may be very important depending on how lobsters fall in the water. The side of lobster vessels is sometimes high (up to 3 feet) and the workable area is far from the water surface. The objective of this study is to work with fishers to develop a slide that enhances the safe return of female lobster to the ocean. Some sea trials will follow. Contact: Damien Grelon (Damien.grelon@merinov.ca).

Thyborøn Pelagic Door on Bottom shrimp trawling with ACPG Innovation:

In 2012, a fishing system equipped with Thyborøn 15VF semi-pelagic trawl doors was adapted and installed on two Québec vessels engaged in the Gulf of St Lawrence shrimp fishery. Two fishing trips were conducted in summer 2012 with two vessels fishing side by side to evaluate and compare the fuel consumption and catch performance of a vessel equipped with 15VF "flying" doors with those of a vessel equipped with conventional bottom doors. The data gathered showed that the flying doors generated fuel savings of 7% on average. As for the catches, no statistical differences in terms of either fishing yield or size structure were seen. This project also showed the importance of monitoring the trawl that allows the skipper to continuously adjust settings to conserve the ideal fishing configuration. Contact: Francis Coulombe (francis.coulombe@merinov.ca).

PDG 2: Reducing impact of Scallop Dredges on seabed:

The main objective is to provide recommendations on possible changes to the scallop dredge and fishing practices in order to ensure sustainable harvesting. More specifically, we will want to: 1) determine the impact of dredging on the seabed; 2) describe the swimming behaviour of scallops in front of the dredge; and 3) assess the proportion of scallops that avoided dredge, in relation to factors like water temperature and the reproductive cycle of the scallop. Contact: Lisandre Solomon (Lisandre.Solomon@merinov.ca).

Upgrading intraspecific selectivity of whelk traps:

The main objective of this project is to develop a whelk trap that would reduce sub-commercial sized whelk catches without affecting catches of commercial sized ones and while staying handy for the fishers. Variations in the size of the mesh have been tested in the past and have given no satisfying results. The selectivity of traps with bottoms made of different materials has been tested. Traps with a bottom made of lobster trap wire have shown the best intraspecific selectivity. Different models of bottoms will be designed and tested to permit to pile traps on each other. Contact: Mathieu Morin (mathieu.morin@merinov.ca)

Studying the vertical distribution of northern shrimp to optimize the shrimp trawl in Quebec's fleet:

The main objective of this proposal is to target the position of northern shrimp in order to reduce the vertical opening of the trawl, allowing energy efficiency improvements and environmental impact reductions. Preliminary tests will be performed using a sonar and camera fixed on the trawl. In parallel, bycatch fish behaviour will be documented with videos to propose a new trawl opening for certain fish species. Depending on these preliminary results, a multi-level trawl may be used to sample quantitatively

the vertical repartition of shrimp following the same objectives. Contact: Marie-Claude Côté-Laurin (marie-claude.cote-laurin@merinov.ca)

Evaluating an optimized sea cucumber drag in terms of efficiency and reduction of environmental impacts:

The main objectives if this project will be to determine if a lightened and optimized sea cucumber drag will be more efficient in terms of captures and reduction of bottom impacts. The gear optimizations include a reduced chain grid and the replacement of the net bag by an extended shrimp-type net bag without any metal codend. The functionality and behaviour of the drag will be tested and documented in the field, and a second phase will involve a catch per unit of effort (cpue) evaluation and a bycatch impact study comparing the actual drag with the optimized one. Contact: Marie-Claude Côté-Laurin (marie-claude.cote-laurin@merinov.ca)

12.4.4 Dalhousie University and WWF–Canada

Shark Bycatch Reduction in Canadian Pelagic Longline Swordfish Fishery:

Deterrent hooks with electropositive metals (neodymium/praseodymium, Nd/Pr) were tested on pelagic longline gear typical for targeting swordfish. The electropositive metals oxidize in seawater and create electric fields, which can alter the swimming and feeding behaviours of several species of sharks, and have the potential of reducing predation and bycatch rates. We tested the null hypothesis that electropositive metals do not reduce shark bycatch or target (swordfish) catch. A total of seven sets (6300 hooks) were deployed in 2011 on the Scotian Shelf in the Northwest Atlantic. For blue sharks and all sharks combined, no significant differences were observed between the treatments whereas the swordfish catch was significantly reduced (by 48%) on the hooks treated with the Nd/Pr. The results of this study show that electropositive metals do not present a practical bycatch mitigation measure for the Canadian longline fishery. Contact: Aurelie Cosandey-Godin (godina@dal.ca)

12.5 THE UNITED STATES OF AMERICA

12.5.1 Massachusetts Division of Marine Fisheries

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

A Network to Redevelop a Sustainable Redfish (*Sebastes fasciatus*) Trawl Fishery in the Gulf of Maine

This multiyear project is a collaboration among netmakers, gear researchers and other scientists, fishers, processors and regulators to increase exploitation of a fully rebuilt stock of redfish once nearly unfishable due to small numbers. The project has multiple components including exploratory fishing, codend selectivity, bycatch reduction, marketing, and outreach. In the past year, fifty-six tows were completed using a commercial fishing vessel and a trouser trawl, testing three diamond mesh codends (114 mm, 140 mm, and 165 mm) together with a 63 mm codend as the non-selective control. Based on the results for individual tows, a predictive model for the effect of codend mesh size on mean L50 and mean SR was established. From this model mean L50 and SR, and confidence intervals were estimated for all three tested codends, incorporating both within and between haul variability by using the selectivity software SELNET.

Simulation of fishing with the three tested codends on the observed population indicated that substantial escape of redfish through codend meshes occurs (48–94%), suggesting that investigation of escape of redfish is warranted to support a sustainable fishery. In collaboration with Pingguo He and Bent Herrmann and others.

CEMFIN/GEARNET: Conservation Engineering Marine Fisheries Initiative

The goal of this collaborative network was to assist industry in transition to output controls by identifying short-term technology transfer and pilot gear projects, based on existing knowledge and experience that could quickly reduce bycatch and avoid weaker stocks. Thirty-five or more projects were developed and funded, and over130 fishers engaged. Projects were in six main areas, with emphasis on fuel savings, trawl and gillnet selectivity, reduction of bottom contact, alternate gears including cod pots, and education. This initiative achieved goals of being more efficient, more effective, and with greater uptake of new fishing technology than previous collaborative research models. Collaboration with Steve Eayrs of GMRI, Pingguo He of SMAST, and others. www.gearnet.org

A Low–Cost, Underwater Self–Closing Codend to Limit Unwanted Catch

This innovative codend reduces bycatch by automatically closing itself off from the rest of the trawlnet after catching a preset, adjustable, volume. Using low-cost hardware, the filling codend initially caused the release of a line that allows the codend to fall back and to cinch shut while allowing other fish in the net to escape. Fieldwork of an improved design was completed in summer 2013 with success; the method awaits commercial adoption when fish stocks improve. It is also being actively promoted by the net designer.

12.5.2 NOAA Fisheries, Northeast Fisheries Science Center (NEFSC)

Henry Milliken (Henry.Milliken@noaa.gov), Eric Matzen (eric.matzen@noaa.gov)

More info: http://www.nefsc.noaa.gov/read/protspp/PR_gear_research/

Evaluation of a Topless Bottom Trawl Design with a 160 Foot Headrope for Fish Capture

After testing at the flume tank at Memorial University, St John's Newfoundland, we reconfigured our topless trawl with restrictor lines to improve the shape of the bottom trawlnet and to improve catch performance during previous work to reduce sea turtle bycatch while maintaining the targeted catch. The results of this evaluation indicate that the 48 m (160 foot) headrope, 24 meter (80 foot) hanging line, topless trawl reduced the catch of summer flounder (*Paralichthys dentatus*) and skates (*Leucoraja* sp.) when compared to the traditional trawl. The mean loss of catch by F/V Darana R was 23% for summer flounder and 12% for skates, the dominant bycatch. Testing that occurred to determine sea turtle reduction, suggested that the topless trawl reduced the sea turtle bycatch by approximately 50%.

Assessment of the Impacts of Gear Modifications in the Monkfish Fishery on Bycatch of Atlantic Sturgeon

We tested an experimental gillnet designed to reduce bycatch of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) and sea turtles while targeting monkfish (*Lophius americanus*) and winter skate (*Leucoraja ocellata*) in the inshore Mid-Atlantic region off Virginia and Maryland. The experimental gillnets were 8 meshes deep with 24 inch tie-

downs compared with commercial gillnets (control) that were 12 meshes deep with 48 inch tie-downs. Two commercial fishing vessels were contracted to do sea trials during May of 2013 with an observer on board each vessel to collect operational and biological data. The nets were fished in pairs; each pair of nets consisted of one control string (10 nets, 50 fathoms each net) and one experimental string of the same number and length. Each vessel completed 50 hauls, 25 hauls of control gillnets, and 25 hauls of experimental nets. Seven Atlantic sturgeons were captured, all from the control nets. The experimental net significantly reduced bycatch of Atlantic sturgeon for each vessel independently and when both vessels' data were combined. The catch efficiency of the experimental nets for monkfish was inconsistent between the two vessels. There were no significant differences between the two types of nets from F/V "Landon Blake" (p=0.60, paired t-test, two-tailed, dof=25), but the Experimental nets caught significantly less monkfish on the fishing vessel F/V "Risky Business" (p=0.012, paired t-test, two-tailed, dof=25) and when both vessels' data were combined. The catch differences were higher when the catch volumes were high. Length frequency and GLMM modelling indicate that the reduction in monkfish catch in "Risky Business" primarily resulted from a reduction in catch of monkfish that were less than 75 cm. There were no statistical differences in the catch of winter skate between the control and the experimental nets for either vessel, or when data for both vessels are combined (p>0.05).

Development and Testing of a Tow Time Data Logger to Monitor and Enforce Tow Time Restrictions in Trawl Fisheries

Tow time restrictions have been discussed as a viable alternative in fisheries where Turtle Excluder Devices (TEDs) are likely to significantly reduce targeted catch. Although the length of time a turtle can remain submerged in a trawl is still being evaluated, tows less than an hour are expected to result in a negligible number of sea turtle mortalities. Discussion about the feasibility of tow time restrictions often results in concerns about the feasibility of monitoring and compliance with any limit on tow times. The Protected Species Branch of the Northeast Fisheries Science Center (NEFSC) for the National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA) solicited a contractor to develop and construct a robust, simple, and inexpensive data logger that can be used to enforce tow-time restrictions on commercial bottom trawl fishing vessels. These loggers, which are attached to the trawlnet or the trawl doors, record the amount of time the units are below a certain predetermined depth and have a signal (light) alarm that can inform enforcement when the unit has triggered this alarm. Additionally, the units have a battery life of approximately four years and can store up to four months' worth of data with the option to overwrite oldest memory. The units were tested for their ability to reliably record trawl fishing times and detect when a tow has exceeded a time threshold. The loggers have been tested on eight vessels operating in six fisheries and have held up to the abuses of the salt environment and the shock and vibration of commercial fishing practices. Additionally, because these loggers are programmable, they may have applications in other fisheries where there is a need to monitor, record, or enforce soak durations. A report on this project should be completed before summer of 2014.

Other NEFSC-identified future projects:

- Seabird bycatch reduction through completing gillnet seabird bycatch estimation analysis (2014–2017);
- Seabird bycatch reduction through completing seabird bycatch estimation analysis for gear type(s) other than gillnets (2014–2017);

- Turtle bycatch reduction in scallop trawl fisheries (2014–2015);

- Continuation of the estimation of bycatch of turtles and marine mammals in Northwest Atlantic trawl, gillnet, pot, dredge and longline fisheries (2014–2017);

- Finfish bycatch reduction in squid, herring, and Northeast multispecies trawl fisheries (2014–2017);

- Atlantic large whale take reduction in fisheries that entangle whales, through the development of gear modifications and other technologies to reduce takes (2014–2017)

12.5.3 Gulf of Maine Research Institute (GMRI)

Steve Eayrs (steve@gmri.org)

Eco-efficiency in the seafood supply chain

In an attempt to build the capacity of fishing enterprises and communities, and improve their sustainability both ecologically and economically, we commenced a pilot-scale project designed to improve operational performance, improve quality and timeliness of data exchange, and improve business decision-making on the part of fishers, processors, and retailers in New England.

This project used Product Integrity Management Systems (PIMS) constructed by Traceall to monitor the temperature and GPS location of seafood from the time it entered the hold of a vessel until the time of delivery at the retail outlet. This information was transmitted at intervals via cell phone technology to a laptop computer, and could then used to i) describe the seafood supply chain, ii) identify instances when low temperature was compromised, and iii) provide an opportunity to apply basic Life Cycle Assessment (LCA) techniques to search for inefficiencies in the supply chain.

The PIMS units accompanied seafood on five separate occasions and temperature trends were observed. Logistically this project proved very difficult given the seafood was unloaded from the vessel, temporarily retained and then sold on the auction floor, transported to a processing facility, then to a holding facility, and finally to a retail outlet. The value of the PIMS was that they provided an opportunity to observe seafood movements from afar and appreciate the complexity of the supply chain. Life Cycle Assessment evaluation using collected data are yet to commence.

This project is a collaboration between the Gulf of Maine Research Institute, New England Trawlers (NET), Inc., and North Atlantic Seafood (NAI), Inc. This work was funded by the National Fish and Wildlife Foundation.

Introduction of electronic vessel trip reports (eVTRs)

As described in the country report from last year, the purpose of this project is to test the feasibility of adopting electronic solutions for vessel logbook reporting across a range of vessels in the northeast groundfish fleet. This includes testing a range of electronic logbook products in conjunction with the NMFS' web-based data entry system to identify obstacles to their use and to ensure compatibility with NMFS' data collection systems.

In fishing year 2013, progress toward the expansion of this project across a greater number of vessels slowed substantially. Of the fishing sectors (cooperatives) we have been working with in 2011–12, most active vessels had been equipped previously with

the system by GMRI and expansion into new sectors had been rendered difficult due to resistance by sector managers and some fishers.

Given this progress, much of the work over the past 12 months transitioned from new equipment setups to refresher training to captains and providing software updates and technical support to the existing user base. Despite this slow down there was still a degree of expansion; the pool of currently active vessels increased from 23 to 25 while the overall pool of vessels equipped and ready to go increased from 32 to 40.

Throughout the year, we also worked with Electric Edge to assist them in developing their new proprietary eVTR software and helping them work through the approval process conducted by NOAA. The software was approved for use in autumn 2013 and has recently begun to be deployed on vessels. This software is primarily used by one specific sector, and with the addition of all boats in this sector reporting electronically it would be reasonable to expect a 20–30 vessel increase in the number of active eVTR users by autumn of 2014. It is worth noting that in the 3 years of this project no captain has tried eVTR then returned back to paper logbook reporting, which indicates a trend towards eventual industry-wide adoption of this form of reporting.

This project is funded NOAA's Northeast Fisheries Science Center and the Northeast Regional Office.

12.5.4 University of Rhode Island Fisheries Center

Escapement from modified lobster/crab traps.

Kathleen Castro (kcastro@uri.edu), Laura Skrobe, Lannie Dellinger and Al Eagles

This project is investigating the use of a shorter escape vent to use when fishing for American lobster, *Homarus americanus* and Rock/Jonah crabs, Cancer spp. These two species are caught in the same gear but the length requirement of the lobster escape vent allows for escapement of Cancer crabs. Two standard lobster traps were placed in a temperature-controlled tank (16º C or 60.8º F) in the Blount Laboratory at the University of Rhode Island. One contained the standard vent (2 x 5 ¾ inch -current regulated size) and the other a slightly modified vent E2 (2 x 3.5 inches). For each trial, 6 sublegal and 2 legal lobsters (haphazardly chosen from large tank with 100 lobsters) were placed into the parlour section of the traps. The funnel from the kitchen to the parlour was blocked to prevent re-entry if the lobster escaped and re-entered trap. The vent size was reduced with a piece of Plexiglas screwed in place. The tank was covered with black plastic and a 16L:8D light cycle was used. Bait (herring) was placed next to water flow. Final results showed that a 3.5 inch vent showed no significant difference in escapement of sublegal or legal sized lobster compared to the currently regulated vent. This project is now being conducted in the fishery.

Catch comparison of two mesh sizes in the bottom gillnet used in the Gambian sole fishery (84 and 92mm)

Gibril Gabis, Geoffrey, Kathleen Castro and Chris Parkins

This study in the Gambia compared the catch composition (size and species) of two net mesh sizes in bottom gillnets: 84 and 92 mm stretched mesh (42 and 46 bar length). The results indicate that significantly larger sole, catfish, Sompat grunt, Bigeye grunt, Lesser African threadfin and butterfish are caught with the larger 92 mm stretch mesh net than in the 84 mm net. Both nets caught most of the same species and the total number captured was not considerably different between the two nets. The increased

mesh size has the potential to be a meaningful management tool for the sole and catfish fisheries while also improving the status of grunt and butterfish. The species that did not show a change were sardinella, Cassava croaker and Bobo croaker. Current mandated minimum mesh and fish size have been arbitrarily determined. New (although not complete) information on sole maturity can now be matched with mean size of fish captured using different mesh sizes. With better biological information, it will greatly improve harvesting rules and fishery sustainability. Preliminary data indicate that 50% maturity of Arius spp. occurs between 20–25 cm lengths. Increasing mesh size to 84 or 90 mm will shift the mean size of fish captured to between 31–34 cm, well above the 50% maturity size.

Effect of Hanging Ratio on the Catch of Red Sole (*Cynoglossus senegalensis*), Black Sole (*Synaptura cadenati*) and Catfish (*Arius* spp) in The Gambian Bottom Set Gillnet Fishery

Gibril Gabis, Lina Kelpsaite, Chris Parkins and Kathleen Castro

The hanging ratio (HR) of gillnets has the potential to influence the mechanism for fish capture by changing the shape of the mesh size. In order to improve the selection potential of the gillnet for catfish, this study examined the catches of three different HRs: 0.25, 0.5 and 0.75. The objective of this research was to characterize the catch of these predominant species in the gillnet with alternative hanging ratios and make suggestions on how to reduce the catch of vulnerable species. The catch comparison information from this study found no difference between mean sizes of each species caught by different HR sections except for Bonga shad. There was no difference in the shape of the length frequency (KS test) between H for the species. Photos taken during fishing trials point to extreme entanglement with the control net. Not only are most fish caught in this manner, but also many bottom dwelling species were found near the floatline. Insufficient floatation allows the net to lie on the bottom during high current situations.

Size selectivity of catfish Arius species captured in the Gambian longline fishery

Geoffrey Kibler, Gibril Gabis and Kathleen Castro (In progress)

Three hook sizes are being tested in the catfish fishery (#7, 9 and 11) as a possible management tool for controlling minimum size of Arius spp catfish landed in the longline fishery. Study has recently finished and data has not yet been evaluated

12.5.5 Consortium for Wildlife Bycatch Reduction

Tim Werner, New England Aquarium (twerner@neaq.org); Center for Ocean Engineering, University of New Hampshire; Maine Lobstermen's Association; Duke University Marine Lab; Blue Water Fishermen's Association

The Consortium for Wildlife Bycatch Reduction is a partnership of fishers, wildlife biologists, and engineers. The Consortium supports collaborative research between scientists and the fishing industry to develop practical fishing techniques that reduce the bycatch of threatened non-target species. Projects supported by the Consortium come under three main categories: (1) Global exchange of bycatch reduction technology; (2) Understanding wildlife interactions in commercial fishing operations; and (3) Research and development of bycatch reduction methods. Some of the Consortium's current projects are described below. Additional details on Consortium projects, including a searchable database of bycatch mitigation techniques, are available at www.bycatch.org.

International Marine Mammal – Longline Bycatch Mitigation Workshop

New England Aquarium

With co-sponsorship from NOAA's Office of International Affairs, the Consortium convened a workshop on October 22–25, 2013 in Woods Hole (Massachusetts) to review research on reducing bycatch of O*dontocetes* in longline fishing operations worldwide. Participants reviewed several methods under evaluation in different parts of the world including acoustic deterrents, weak hooks, and net sleeves. Workshop outputs will include a special issue of the ICES JMS on this topic.

Evaluation of an electric decoy to reduce elasmobranch bycatch in the eastern Atlantic and Gulf of Mexico

Blue Water Fishermen's Association, Florida Atlantic University, Florida State University, New England Aquarium, NOVA Southeastern University

Fishery-independent longline surveys were conducted in the Gulf of Mexico to test the efficacy of using electric decoys. Preliminary analysis of data suggested a 47% reduction in elasmobranch species, with higher and lower figures for particular species. The electric decoys are currently being tested aboard a commercial pelagic longline vessel in the Southeastern US swordfish fishery.

New England Aquarium, Program in Marine Conservation Engineering

Tim Werner, New England Aquarium (twerner@neaq.org)

Area displacement trials with marine mammals using acoustic pingers

Acoustic pinger trials were carried out with the Chilean dolphin (*Cephalorhynchus eutropia*) in Chile, and the Ganges River Dolphin (*Platanista gangetica*) in Bangladesh. The Chilean dolphin trial results were presented at the Society for Marine Mammalogy's 2013 meeting in New Zealand, and are being written up for publication. A report on the Ganges River Dolphin trial will be posted on the NEAq website in June of 2014.

Evaluation of acoustically reflective/physically stiffened gillnets in Argentina

See:

Bordino P, Mackay AI, Werner TB, Northridge SP, Read AJ (2013) Franciscana bycatch is not reduced by acoustically reflective or physically stiffened gillnets. Endang Species Res 21:1–12

Feasibility of using pingers in an artisanal fishery of northern Argentina

With co-PI Pablo Bordino (Aquamarina); we are testing how bycatch rates of the endangered Franciscana dolphin (*Pontoporia blainvillei*) differ using variable numbers and spacing of pingers along the length of gillnet strings. Previous research showed that pingers resulted in reduced bycatch of franciscana dolphins. The study was designed to determine the effects of using a reduced number of pingers, an important consideration in terms of cost to local fishers as well as issues of compliance and the consequences of malfunctioning pingers.

Evaluating fishing pots as an alternative fishing gear to gillnets in the Bahia de Samborombon, Argentina

With co-PI Pablo Bordino (Aquamarina), we are implementing a field trial to compare catch and bycatch rates between standard local gillnet gear and a new type of fishing pot. We will also examine the financial returns of using both gear types, and practical operational considerations for local fishers.

12.5.6 University of Massachusetts Dartmouth

Marine Fisheries Research Group

Kevin Stokesbury (kstokesbury@umassd.edu)

Broad–scale video survey of the US east coast sea scallop resource 2014.

The US sea scallop fishery is managed under an area rotation system requiring spatially specific information on scallop density and size. The SMAST–Industry cooperative video survey provides this type of information with high levels of accuracy and precision. Since 1999, SMAST has completed 148 video cruises surveying Georges Bank and the Mid-Atlantic (>1000 days at sea), with support from the commercial sea scallop industry, the Massachusetts Division of Marine Fisheries (MA DMF), and the sea scallop RSA program (NOAA grants). This unique database covers the entire scallop resource (~70,000 km^2) from 2003 through 2012. A centric systematic sampling design with stations on a 5.6 km^2 grid, with four quadrats sampled at each station, is used to survey all areas. Further, the database includes numerous video surveys on a finer spatial scale focusing on scallop aggregations primarily in areas of Georges Bank and the Mid-Atlantic closed to fishing. The sampling pyramid is deployed from a scallop-fishing vessel. Two downwards-looking live feed video cameras and a 10 megapixel digital still camera provides 2.84 m^2, 0.60 m^2, and 1.06 m^2 views, respectively, of the seabed. A fourth live feed video camera provides a horizontal view across the seabed. All scallops and other macro-benthos are counted. This information is an important contribution to area-based management as it provides spatially and temporally specific distributions, absolute abundance, and size structure of scallops in closed and open areas of Georges Bank and the Mid-Atlantic. The abundance data are converted to exploitable biomass estimates for the entire resource and each subarea. The scallop industry has asked us to conduct this survey in 2014 to continue this time-series.

Alternative groundfish surveys using advanced video imaging technology.

SMAST is developing a new groundfish survey technology that combines traditional fishermen's knowledge with advanced video imaging techniques. The objective is to explore and develop a non-intrusive, efficient survey to investigate the abundance, spatial distribution, and size structure of the Georges Bank yellowtail flounder stock. The "video survey" involves local fishers, use industry vessels, and partner with a local fishing gear manufacturer. The survey also fully utilizes SMAST's strength in field video equipment operations, imaging analysis, spatial statistics, and stock assessment. While we concentrate on yellowtail flounder at this moment, the video survey method can be readily applied to other flatfish and roundfish in the multispecies groundfish complex on Georges Bank and other areas in the Northeast. The result from initial testing of this technology is encouraging. We have conducted three surveys to date; a pilot study in the spring 2013, a fall survey in the southern portion of closed area II on Georges Bank giving an estimated biomass of 1432.0 mt of yellowtail flounder (95% CL 555.7 and 2308.3) representing 6.5% of the stock area; and a third survey in spring 2014

which is being processed now. Continued support for this non-capture ecosystem-based sampling effort is essential to provide alternative assessment for critical groundfish species.

River herring bycatch avoidance project. N. David Bethony (nbethoney@umassd.edu).

The incidental catch of river herring by vessels targeting Atlantic herring and mackerel has become a concern for their conservation. Though the direct effect of this bycatch on river herring populations is unknown, managers have created river herring catch limits. If river herring catch limits are reached, large areas of the Atlantic herring fishery or the entire mackerel fishery could be closed. Since 2010, the MA DMF and SMAST have partnered with midwater trawl fishers and Rhode Island bottom trawl fishers to reduce river herring and shad bycatch independent of management action; aiding in the effort to rebuild river herring and providing fishers with a tool to avoid area closures. The collaboration involves increasing portside sampling, a near real-time information system on the location bycatch events, and testing if oceanographic features can be used to indicate areas with a high probability of bycatch. The project was started with funding from the National Fish and Wildlife foundation. It is now sustained by The Nature Conservancy and the Atlantic herring RSA program.

Use of the SAFE Index to Evaluate the Status of a Summer Aggregation of Atlantic Sturgeon in Minas Basin, Canada and the Implication of the Index for the USA Endangered Species Designation of Atlantic and Shortnose Sturgeons.

Sturgeon species worldwide have undergone population declines due to habitat alteration and overexploitation and many are listed by the International Union for Conservation of Nature (IUCN) and national agencies. Atlantic and shortnose sturgeon on the east coast of North America are listed as 'endangered' or 'threatened' over most of their ranges. It has been proposed, however, that IUCN risk categories are ambiguous and do not consider the threat status of a species in relation to a minimum viable population level. We examined the Species Ability to Forestall Extinction (SAFE) Index, which is a heuristic measure of a species relative distance from extinction, and other available information on Atlantic and shortnose sturgeon with regard to the risk status of the two species. To move beyond a 'tipping point' designation of threatened; the SAFE Index requires a species abundance of 5,000 adults (SAFE Index = 0.0). DNA and mark-recapture data for Atlantic sturgeon in Minas Basin, Canada indicated an aggregate USA/Canada mixed-stock of ~10,000 fish in summer. The SAFE Index for this population is 0.28, indicating abundance is within the 'vulnerable' threshold range for the SAFE Index although it includes but a small portion of the Atlantic sturgeon in the western Atlantic. Estimates for the east coast of North America suggest the Atlantic sturgeon population could consist of ~177,000 sub adults and adults for a SAFE Index of 1.55. Additionally, the present spawning range of Atlantic sturgeon in North America is ~99% of the historically known range and the number of stocks is near the historic level (33+) which means the species does not meet IUCN criteria for listing. Similarly, shortnose sturgeon has an Atlantic coast population of ~96,800 adults (SAFE Index of 1.29) and a species range and number of stocks (26+) that has not changed substantially from the historical situation. Since the abundance of Atlantic and shortnose sturgeon are well above the SAFE threshold for 'threatened' and they lack other accepted criteria for endangered or threatened designation, we conclude that the risk status of both species should be reconsidered. (In press, Reviews of Fisheries Science, Stokesbury *et al.*, 2014).

Fish Behaviour and Conservation Engineering Group

Pingguo He (phe@umassd.edu)

Testing of a modified otter trawl groundgear to reduce the catch of juvenile cod and flounders.

A modified Rubber Riser groundgear with escape windows was tested on Georges Bank and Southern New England to reduce overfished flounders while targeting cod and haddock. Sea trials were completed in April 2014.

Redfish codend selectivity and mortality.

In collaboration with Massachusetts Division of Marine Fisheries, we are conducting a redfish codend trawl selectivity project. The project compares selectivity properties of three codends: 4.5, 5.5, and 6.5″ diamond mesh sizes on board a commercial fishing vessel using the trouser-trawl method. Sea trials have completed with data analysis continuing. A new project phase on assessing escape of redfish at different stages of capture and on reducing small redfish at fishing depth will be carried out this summer.

Elasmobranchs electro–magneto–reception and their conservation.

Craig O'Connell, post-doctoral fellow in the group, is carrying out several projects investigating electro-magneto-reception of elasmobranchs and its application in hook and line fisheries to reduce bycatch of spiny dogfish and in beach nets to reduce mortality of large predatory sharks. DIDSON ARIS acoustic camera was used to examine behavioural differences between day and night.

Scallop dredge.

A project to re-design the New Bedford-style scallop dredge to reduce yellowtail flounder bycatch and to reduce fuel costs and seabed impact during dredging has started. The dredge incorporates wheels and hydrodynamic pressure plates so that it does not have to dig into the substrate. Sea trials were completed in fall 2013.

Test of topless shrimp trawl for North Carolina shrimp fishery.

In collaboration with North Carolina Division of Marine Fisheries, a new project to test a topless shrimp trawl design in the in Pamlico Sound has just been funded. The project will test a topless shrimp trawl to reduce finfish bycatch and sea turtles.

River herring behaviour.

In collaboration with United States Geological Survey (USGS), a project to determine river herring behaviour when migrating upstream to the river through coverts and tidal gates is being underway. We will use DIDSON ARIS acoustic camera to document movement of river herring as well as predatory species such as striped bass at the estuaries and river mouth. This will be in addition to acoustic and electronic tagging and positioning studies carried out by USGS.

12.5.7 Oregon Department of Fish and Wildlife

Bob Hannah (bob.w.hannah@state.or.us), Steve Jones, Polly Rankin, Matthew Blume

Evaluating the effect of "footrope windows" on demersal fish bycatch in ocean shrimp trawls.

The third season of research evaluating footrope windows in ocean shrimp trawls for bycatch reduction of eulachon was completed. Footrope windows decreased eulachon bycatch, but at comparable levels to the shrimp loss they caused. A final project report is available free at: http://www.dfw.state.or.us/ MRP/publications/

Estimating discard mortality of rockfish with barotrauma.

Field studies to generate cage-based estimates of short-term discard mortality (post-recompression) of Pacific rockfish in the recreational hook and line fishery (primarily canary and yelloweye rockfish) were completed out to capture depths of 174 m. Yelloweye rockfish continued to show high survival rates, however canary rockfish post-recompression survival declined to just 25%. A manuscript describing the results from this study is currently "in review".

The influence of bait and stereo video on the performance of a video lander as a survey tool for marine demersal reef fish.

A field study evaluating the effect of bait on fish counts with a stereo video lander and the effectiveness of stereo video for generating precise fish lengths and distances from the cameras was completed. Bait increased the mean counts of most demersal fishes and increased the efficiency of stereo video for estimating fish length and distance by bringing many species closer to the camera system. A manuscript describing the results from this study is currently "in review".

Changes in benthic macroinvertebrate populations at Nehalem Bank 6 years after trawl closure.

We completed a re-survey of the mud habitats around Nehalem Bank with ROV to evaluate changes in benthic macroinvertebrate populations 6 years after some of the sites were closed to all trawling. All 4 areas, 2 closed to trawling and 2 in which trawling continued, showed large increases in sea whip densities in 2013, with size frequencies indicating a high level of recent recruitment. A report describing the results from this study is available free at: http://www.dfw.state.or.us/MRP/publications/

Future work:

- In a collaboration with Mark Lomeli of Pacific States Marine Fisheries Commission, we will study the effect of artificial light on BRD performance and escapement of bycatch species at the footrope of an ocean shrimp trawl.
- We will evaluate the effect of the colour of artificial lighting on the performance of a stereo video lander for surveying rocky reef fishes, as a function of ambient light levels.
- Additional field and lab studies to evaluate the longer-term health effects of capture and associated barotrauma on yelloweye rockfish will be conducted.

12.5.8 NOAA Fisheries, Alaska Fisheries Science Center (AFSC)

Carwyn Hammond (carwyn.hammond@noaa.gov), Scott McEntire (scott.mcentire@noaa.gov)

Salmon Excluders–RACE MACE.

We continued our collaboration with industry on new designs for salmon excluders. Efforts have focused on testing and improving a new design that would allow escape from both above and below, resulting from a previous flume tank workshop. We began by participating in a model testing/development workshop at the flume tank in St Johns, Newfoundland. The North Pacific Fisheries Research Foundation placed a technician aboard Gulf of Alaska vessels to demonstrate correct tuning and operation of the new excluder design to promote transfer of this technology to that fleet. The AFSC provided the camera systems used by this technician from our CE "loaner pool." This work was conducted in both the Bering Sea and the Gulf of Alaska Pollock trawl fisheries. There has been no substantial change in Chinook and Chum salmon escape rates. Pollock escape was insignificant at less than 1%. Because the new excluder system includes more and larger escape portals, escapes are being monitored with video instead of the more cumbersome recapture nets. The CE program developed a much more compact camera system for this work and up to six of these have been used during the same tow. This new camera system is expected to see wide use on Alaska fishing vessels. An additional model testing/development workshop at the flume tank in St Johns, Newfoundland was conducted in fall of 2013, including improvements to the new design and tests of new designs.

Develop alternative trawl designs to effectively capture pollock concentrated against the seabed while reducing bycatch and damage to benthic fauna.

The Alaska pollock fishery requires the use of pelagic trawls for all tows targeting that species. During some periods of the pollock fishery, these fish concentrate against the seabed and, to capture them, fishers have to put nets designed for midwater capture onto the seabed. We are developing footropes raised slightly off the seabed to have less effect on seabed habitats than the continuous, heavy footropes (generally chains) currently required on pelagic trawls. We have held several workshops with 20+ participants, including captains of pollock trawlers and industry representatives, as well as federal and university scientists to come up with ideas for alternative footropes to test. In May 2014, we will begin exploring these possibilities with experiments to compare the seabed effects of the different alternative footropes.

Development and Evaluation of Trawl Groundgears that Produce Less Damage to Crabs in Soft Bottom Areas–RACE MACE.

In May, CE scientists continued the work from 2012 and 2013 but incorporated feedback from the Bering Sea flatfish trawl fleet to test alternative bottom trawl footropes to reduce potential damage to crabs. CE scientists spent two and half weeks testing alternative footrope designs, including those provided by the flatfish trawl fleet, for crab mortality rates, flatfish capture efficiency, and crab bycatch rates aboard the F/V Great Pacific. Reflex scans were conducted on recaptured crabs and converted to mortality rates with a relationship between reflex loss and delayed mortality (RAMP) developed in prior years. We found that widening disk spacing, and hence reducing ground contact and potential for crab damage, had little effect on flatfish catch rates and improved crab mortality rates.

Provide underwater video systems to fishers and other researchers to facilitate development of fishing gear improvements.

We have continued to provide five underwater video systems to be used by the fishing industry to allow them to directly evaluate their own modifications to fishing gear. Beyond their direct use, exposure to NMFS systems has motivated many companies to procure similar systems for dedicated use on their vessels. Either way, the goal of better understanding of fishing gear operation and quicker development of improvements is being realized. Delivery, training and maintenance have been managed by contractors in the ports of Dutch Harbour and Kodiak with established contacts with the fishing industry. While the existing camera systems have been maintained, a significant advance in this area has been the development and testing of much more compact and inexpensive camera systems for use on commercial fishing gear. All camera system components are enclosed in a single 3.5 inch diameter acrylic tube mounted on a plastic plate. The entire system measures 21 x 10 x 9 inches and is of nearly neutral buoyancy in water. Two test trips (Kodiak and West Coast) and production use aboard the salmon excluder experiment have proven these to be very easy to use, durable and flexible. Six new systems will be built for our use and potential replacement of the older loaner systems. However, this design may be so inexpensive and functional that enough vessels will acquire their own systems and the loaner concept will no longer be needed.

12.6 SWEDEN

12.6.1 Swedish University of Agricultural Sciences

Contact: Hans Nilsson (hans.nilsson@slu.se), Joakim Hjelm, Johan Lövgren, Sven-Gunnar Lunneryd and Sara Königson

A new Secretariat at SLU to help the fishery to implement the new Common Fishery Policy (CFP), with special focus on the landing obligation

This secretariat main task´s is to collect ideas from the industry, making project out of them and after development test them scientifically. The secretariat is founded by the Swedish Agency for Marine and Water Management and is a four-year commitment from the government. The first year main focus area´s is selectivity in the Baltic cod fishery, the Western shrimp and Nephrops fishery, and the survival of salmon in the Baltic fishery on whitefish.

Development of size selectivity in the Swedish grid

This project is collaboration between gear researcher and local fishers to include size selectivity in the Swedish grid on the target species *Nephrops norvegicus*. The size selectivity on Nephrops is obtained by a dual grid system with a lower panel with 22mm bar distance and an upper panel with 40 mm bar distance. The later work has been focused on different codend solutions including diamond mesh to remove flatfish and square mesh windows to reduce bycatch of smaller cod´s passing the grid system.

Development of size selectivity in the shrimp grid

This project is very much the same as the project "Development of size selectivity in the Swedish grid " and is collaboration between gear researcher and local fishers. In this project the focus is on size selectivity on the target shrimp species Pandalus borealis using a dual grid system.

Development of size selectivity in set trap

Studies investigating alternative fishing gear such as traps for species like pike-perch and herring have been carried out by the Department of Aquatic Resources, the Swedish University of Agriculture Science. Since July 2011 this research is conducted by the Department of Aquatic Resources of the Swedish University of Agricultural Sciences (SLU). Set traps for pike-perch are being tested in areas along the Swedish Baltic coast by local fishers.

Development of cod pots

A Swedish fishing gear company Carapax has planned a project with funding for the next year to develop a full-scale cod pot fishing method. The project mainly focuses on how to improve the construction of the pot as well solutions for better handling of the pots on board. The outcome of this project may be of interest to evaluate in terms of bycatch reduction as well as consequences for the fisheries.

At the Swedish south coast development and testing of alternative fishing gear such as cod pots has been conducted. The South Coast Fishing Area (Sydkustens fiskeområde) operates experimental fishing project with cod pot in collaboration with local fishers and scientists at SLU. The goal of the project is to develop an effective cod pot to be used in a future small-scale pot fishery. The project is in collaboration between the municipalities of Sölvesborg, Kristianstad, Simrishamn and Ystad. In 2013, this project also started collaborating with the Department of Aquatic Resources, the Swedish University of Agriculture Science to get a more scientific approach on the project. Several different models of pots have been tried out and the results are promising. The pots fish around 2 to 7.7 kg cod per emptying.

The Department of Aquatic Resources, the Swedish University of Agriculture Science has carried out a project to try to find out why cod pots do work and are efficient in catching cod in certain areas and do not work in other areas. Parameters as prey in the area, current, state of the fish might impact.

12.7 SCOTLAND

12.7.1 Marine Scotland – Science

Trials to investigate the physical impact of towed gear components on the seabed.

Contact: Barry O'Neill b.oneill@marlab.ac.uk or Keith Summerbell k.summerbell@marlab.ac.uk

Sea trials were carried out on the RV Alba na Mara during the 3–14 October 2013 in the Moray Firth, Scotland to investigate the physical impact of trawl gears on the seabed. A specially designed towed sledge was used to explore the hydrodynamic forces, the associated mobilization of sediment and the geotechnical forces acting on different cylindrical components (groundgear disks, clump weights, etc.). Particular reference was given to the effect of size, weight, aspect ratio, towing speed, and whether a component is rolling or not.

The hydrodynamic drag coefficient values obtained were very similar to what is in the engineering literature. We also showed that while the weight of a component does not influence the amount of sediment mobilized, the towing speed does. This supports the

view that sediment mobilization is essentially a hydrodynamic process and that the quantity of sediment mobilized is related to the drag of the gear component.

We showed that the contact drag per unit area is primarily related to weight per unit area exerted by a gear component. There may also be secondary effects related to towing speed, as there is an indication that as the contact drag decreases as speed increases, which may be due to the gear component penetrating the substrate less. There were also differences between rolling and fixed components.

Investigating the potential of fisheries selectivity to promote sustainability.

Contact: Barry O'Neill b.oneill@marlab.ac.uk

An age structured population model parameterized for a wide range of stocks was used to study the effects of selectivity on SSB and yield. For this, a generic selectivity metric, namely the difference between mean age-at-capture and mean age-at-maturity, was introduced. The effect of selectivity on SSB and yield is compared to the respective effects of exploitation rate and biological parameters, using Generalized Additive Models (GAMs). We show that yield is mainly driven by biological parameters, while SSB is mostly shaped by the exploitation regime. Selectivity is more influential than exploitation rate for both yield and SSB. Catching fish a year or more after they mature combined with an intermediate exploitation rate ($F \approx 0.3\,y\,1$) promotes high sustainable yields at low levels of stock depletion. Empirical exploitation regimes of 31 ICES stocks are compared to the optimal regimes identified by the simulation analysis, illustrating the unfulfilled potential of most empirical stocks for higher sustainable yields due to high juvenile selection.

Comparative trials to assess the effect of a 'tickler' chain on skate and ray species

Contact: Rob Kynoch r.kynoch@marlab.ac.uk

Paired comparative fishing hauls were made using groundgear escape bags with/without a tickler chain to evaluate its effect on the retention of skate and ray species. Trials were undertaken on RV Scotia during October 2014 on commercial fishing grounds around the west coast of Scotland. The trawl used was A Jackson Trawls (Peterhead) monk trawl, which is used to conduct Marine Scotland Science annual anglerfish survey. Preliminary results suggest the use of a tickler chain significantly increases the catch of skates and rays.

Development of a 45mm Flexible Grid for Nephrops trawls to increase Monkfish Retention

Contact: Jim Drewery j.drewery@marlab.ac.uk or Rob Kynoch r.kynoch@marlab.ac.uk

With input from SEAFISH and Stornoway Plastics, Stornoway, a 45mm flexible grid (as trialed in 2013) was redesigned with potential to increase the low monkfish retention observed during the trials. The new design incorporates a top panel lacking rigid bars (anglerfish opening) but which has flexible 'fingers' attached to the upper or lower horizontal bar. These stretch completely across the panel but can be depressed however by moderate pressure allowing access to the codend. The design hopes to exploit differences in behaviour between monkfish and gadoids, with the 'fingers' potentially still providing an effective barrier for gadoids inducing them swim out through the escape gap above, but allowing the more passive monkfish to fall through into the codend. The open panel at the bottom was reduced from 200mm to 150mm. Apart from

some in situ observations on rigging this design is still untested in terms of commercial fishing.

Preliminary observations were made on the monk grid during March 2014 on Marine Scotland research vessel Alba-na-Mara. During the cruise, the anglerfish opening was rigged with a 60mm mesh size collection bag to enable an assessment of the fishing passing between the 'fingers'. A mini camera was mounted onto the top sheet netting ahead of the grid and fish outlet hole to assess escapees out of the gear. However, due to the depth encountered artificial light had to be used throughout the cruise.

Initial observations suggested anglerfish were encountering the grid as expected, but only very small fish (<30cm) were encountered during the cruise and none appeared to have sufficient weight to open the 'fingers'.

12.8 PORTUGAL

12.8.1 IPMA – Portuguese Institute for the Ocean and Atmosphere

Analysis of fishing strategies and tactics in Portuguese coastal trawlers

Contact: Aida Campos (acampos@ipma.pt); Paulo Fonseca (pfonseca@ipma.pt)

Fishery-dependent data from the Portuguese coastal fish trawl fleet were integrated examine fleet segmentation and dynamics, spatial-temporal patterns of activity and to estimate species-directed effort and abundance along a 13-year time-series.

Individual vessel trajectories obtained from processed VMS data are being analysed in order to characterize a number of operational and economic parameters, for the different landing profiles (LP) in the fishery, corresponding to fishing trip types with specific landings composition. This information is combined with fuel consumption estimates for the distinct phases of a round fishing trip, providing an insight into the profitability of fishing operations. Differences in fuel consumption and overall economical efficiency among LP may indicate whether there will be room for changes in operational procedures to improve fishers' return.

Fuel efficiency in trawlers

Contact: Joaquim Parente (jparente@ipma.pt); Paulo Fonseca (pfonseca@ipma.pt)

IPMA is currently at the early stages of a fuel saving project (CONSUPESCA) to be carried out on-board Portuguese fish bottom trawlers targeting horse mackerel and cephalopods, in collaboration with the fishing industry. The work focus mainly on the improvement of the technical aspects of the fishing gear, namely the adoption of high-tenacity netting in place of the commonly used PET. The adoption of new otter boards designs will also be evaluated.

Cooperation with the industry and other stakeholders to reduce discards

Contact: Aida Campos (acampos@ipma.pt)

A cooperative platform was established between the South Western Waters Regional Advisory Council (SWW RAC) and several research institutions at the scope of the project SIMBAD (Strategies at Sea to Reduce Discards). The objective of this study is to propose strategies to decrease the volume of discards generated by fishing boats in the Bay of Biscay and Iberian Peninsula waters.

A description of the Portuguese trawl métiers and associate landing profiles to highlight the respective discarding patterns was carried out. Port meetings have been organized with fishers in order to improve our knowledge of the main species discarded and reasons for discarding, as well as to look for jointly agreed solutions to facilitate their implementation.

Evaluation of the impact of adopting gear–based management measures in the Portuguese crustacean fishery

Contact: Paulo Fonseca (pfonseca@ipma.pt); Aida Campos (acampos@ipma.pt)

Several studies show that the Portuguese bottom trawl crustacean fleet targeting the rose shrimp and the Norway lobster has a high level of bycatch and discards. The main bycatch species include the blue whiting, horse mackerel and hake. At the scope of the EcoFishMan project (ref) the bioeconomic impact of different selective devices was assessed over a 20-year simulation period. The experimental selective devices were previously evaluated through at-sea selectivity experiments. Using a knowledge-based model for the Portuguese bottom trawl crustacean fleet, different scenarios were compared to the status quo. Simulations show positive impacts on the target species SSB with small reduction in the long-term revenues.

12.9 NORWAY

12.9.1 Institute of Marine Research (IMR)

Developing responsible purse–seine fisheries

Previous experiments have shown that slipping of herring and mackerel from purse-seines after hard crowding may lead to high mortalities among released fish, and such practices should not be allowed as a means to regulate catches. Catch regulation by slipping in purse-seine fishing is in need of a total makeover in order to conform to current ambitions regarding animal welfare and sustainable resource management. The Norwegian fisheries management has therefore suggested a need to revise the legislation on slipping in these fisheries. Excessive catches or unwanted size and/or quality are the two main reasons for slipping catches in the purse-seine fisheries for pelagic species. If species, size, and abundance/density could be monitored at an early stage of pursing, unwanted catch could be released with minor stress and insignificant slipping mortality. IMR is therefore putting effort into developing instrumentation for early identification of purse-seine catches. In addition, a sampling device for obtaining a physical sample of the catch for quality assessment in an early stage of seining has been developed. This system consists of a small sampling trawl (kept open by kites) which is shot into the seine with a specially designed air gun and towed back to the vessel using a small winch.

If a vessel, for whatever reason, casts its net on suboptimal fish, or casts on too big a shoal, technology is needed to slip some or all of the enclosed fish as gently as possible. The purse-seines used today are constructed with the aim of maximizing catch quantity with no focus on sustainability or environmental effects. IMR have therefore focused on developing seine designs and seining techniques to facilitate quick release of fish with a minimum of stress and abrasion. This has been done by introducing modifications to the bunt (the part of the net where the catch is collected in late stages of pursing) and methods to enable rapid and ample opening of the seine. The Norwegian fisheries authorities will in the coming year evaluate if these modifications should be

recommended as "preferred practice" for the purse-seine fleet. Contacts: Aud Vold (aud.vold@imr.no), Jostein Saltskår (jostein.saltskaar@imr.no).

Shrimp grid modifications to retain bycatch of Nephrops

The use of sorting grids was made mandatory in the Norwegian trawl fishery for Pandalus in the Skagerrak from 1 January 2013. To retain the bycatch of fish the legislation provides for the use of a collection bag with a 120 mm square mesh selection panel over the grid outlet. With a 19 mm bar spacing in the shrimp grid, only the very small Nephrops are able to pass through the grid and into the codend. The majority slide along the grid and enter into the collection bag where a large fraction escapes through the selection panel. This escape represents an economic loss to the fishers of a well-paid bycatch species.

Comparative fishing trials with a standard shrimp grid and a grid with a 10 cm high slot at the lower end showed that the codend catches of Nephrops more than doubled when the slot was used. At the same time, the slot did not result in a significant increase in the bycatch of fish. When fishing with a standard grid, Nephrops was observed to accumulate in front of the grid. The whole or part of this catch may be lost during hauling during bad weather or when the codend is twisted. Including the Nephrops ahead of the grid in the catch figures reduces the catch gain from using the slot to 40%. Contact: Terje Jørgensen (terje.joergensen@imr.no).

Survival and catch experiments on wrasse

Wild-caught wrasse are used in aquaculture industry to remove sea lice from salmon. The survival of wrasse in the pens can be influenced by a number of factors such as for example temperature, maturity, physical status and handling. During trials, fykenets and pots were used to catch wrasse (*Ctenolabrus rupestris, Symphodus melops, Labrus bergylta, Centrolabrus exoletus*). The fish were transferred into pens. The results show no correlation between survival and the number of fish in the pens (densities up to 20 fish per m³). No significance differences in survival were found when comparing fishing gears (traps and pots) or soaking time. There is a minimum size of wrasse of ≥11 cm. Fish below this size should be released back into the very spot it was caught. One of three wrasse caught in fykenets are below this size – and one of two in pots. Thus, to reduce the stress on the wrasse and the workload of the fisher, size selection devices were tested out in both fykenets and pots.

In pots, a selective grid with ten 13x75 mm openings was found to be the most effective, giving a reduction of 52% in proportion of undersized wrasse. Likewise gave a single escape hole (of 13x75 mm opening) positioned at five different locations in the inner chamber of the fykenet a 72% reduction in proportion of undersized wrasse. Video recordings from traps and pots have been carried out in order to analyse behavioural differences between species and gear types. Sea trials with larger escape holes will continue in 2014, this time to see if it is possible to fish selectively on larger (> 13 cm) *Labrus bergylta*. Contact: Anne Christine Utne Palm (annecu@imr.no).

Catch control in the Norwegian demersal seine fisheries

With today's large cod stock, it has become a great challenge for the demersal seine fleet to limit their catch sizes. This project's objective is to develop a solution that allows the vessels to control their catch sizes. In 2013, underwater observations were made during commercial fishing with dense aggregations of cod. In addition, prototypes for alternative solutions were tested in a flume tank. Experiments in 2014 have resulted in

a functional solution that has gained industry acceptance. Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no).

Down-scaling of square mesh codends for demersal seines

In fishing areas east of Sørøya, N-Norway, the use of square mesh codends with specified minimum length and circumference is mandatory in the demersal seine fisheries. Handling these large codends is difficult for the smaller boats. The objective of this project is to measure size selectivity of a scaled-down square mesh codend and that of the larger, legal version for management advice. Codends have been tried by commercial fishers as a pre-project and selectivity experiments will be performed in 2014. Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no).

Species selectivity in the Norwegian demersal seine fisheries

The availability of Atlantic cod and haddock on the fishing grounds and corresponding quotas has not always gone hand in hand. At IMR, Bergen, a species selection device for separating cod and haddock was tested in the late 90's. With arising need, the dust has been wiped off that concept; it has been filmed in the commercial seine fishery and tested in a flume tank in 2013. Direct measurements of the performance of the device as well as underwater filming will be performed in august 2014. Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no).

Development of cod pots

Fishing trials with floated and bottom-set two-chamber cod pots have been carried out in different areas and seasons. The fishing trials that were carried out in Vesterålen (northern Norway) in April 2013 gave high catch rates of cod for the two-chamber pot. Pots set on the bottom and pots floated about 1 m above the bottom had catch rates of 6,3 (35 kg) and 5,3 cod per pot, respectively. Trials carried out in a fjord close to Tromsø (also northern Norway) in September 2013 also gave high catch rates of cod. In these trials pots floated just above the bottom (35 cm) gave higher catch rates than both pots set on the bottom and pots floated about 1 m above the bottom. Preliminary analyses of video recordings indicate that cod approaching the pots were searching just off the seabed. Contact: Svein Løkkeborg (svein.lokkeborg@imr.no).

Pelagic sampling trawl

The DeepVision camera system has been developed by Scantrol AS to register and identify organisms that pass the system during trawling (Rosen *et al*., 2013). During a cruise with the RV Johan Hjort in connection with the Joint Norwegian/Russian Ecosystem survey in the Barents Sea in 2012, the DeepVision system was installed between the extension and the codend of the Harstad trawl used for sampling in the upper pelagic zone.

The trials showed that it was possible to identify, quantify and measure the length of most of the individual fish that passed the DeepVision system during trawling. When the trawl was hauled after standard trawling procedures had been completed (trawling at three depths), the observations showed that significant numbers of polar cod and Greenland halibut had passed the camera system, particularly at the surface. Based on these observations, we assumed that these were fish that had been snagged in the meshes ahead of DeepVision during trawling and had come loose when the net was hauled. When the trawl was bought on board, fish were found still snagged in the net, particularly in the smaller meshes (60 and 80 mm).

The reason that snagged fish come loose and pass the DeepVision system, particularly near the surface, is that the net is both slackened and tightened during this phase of hauling (for instance, when the trawl-doors reach the gallows), and this tends to release the fish. Wave motion at the surface can also affect the trawlnet in ways that cause the fish to be released.

Variations in hauling procedures and weather conditions can thus influence how many fish are released from the meshes, and thus also the total catch and the index that is calculated on the basis of the catch rate. The fact that fish become snagged in the meshes also indicate that an unknown number also pass out through the meshes of the trawl and are not retained in the catch.

In the Norwegian krill fishery in the Antarctic, the problem of krill clogging the meshes during towing was solved by the addition of fine-mesh inner nets that were mounted only at the leading edge to the outer net. Since the sections are only attached at the leading edge to the outer net, the water flow keeps them in movement, thus preventing krill clogging.

During trials in 2013 similar fine-mesh inner nets were mounted inside the extension of the Harstad trawl. Four inner nets (8 mm mesh), each 6 m long, were mounted to the outer net as described above. The inner nets overlapped by about 1.5 m, and the end of the rearmost inner net was about 1.5 m inside the codend.

The underwater observations showed that the inner nets functioned as intended. The inner nets, particularly their rear parts, were in continuous motion, which meant that small organisms did not become snagged during towing. The mesh size of only 8 mm also prevented small fish from escaping from the net. Measurements of the geometry of the two trawls, both with and without the inner nets mounted, showed that it was very similar when the leading inner net was mounted on the trawl itself. The vertical opening was about 6 m in this area, while the horizontal opening was around 5 m. At the entrance to the codend, the geometry changed; with the inner nets installed, the vertical and horizontal openings were about 3.6 m and 3.4 m respectively, while without the nets they were 1.5 m and 1.4 m respectively. The difference in the dimensions of the opening at the entrance to the codend was also observed via the video camera.

These measurements and observations show that the fine-mesh inner net helps to increase entrance diameter of the codend. In the area where the inner nets are mounted, the trawl is cut at a high angle, and we believe that the increased dimensions are due to a combination of the high angle and the fine mesh, which balloons out as it is drawn through the water.

Water flow sensors mounted at the headline and the rear of the trawl (in the areas of 120 mm mesh where the inner net was mounted and the entrance of the codend) showed that there was no difference in flow by position on with and without the inner nets.

Catch rates were low in these trials. Further trials with inner-nets and DeepVision will be carried out in 2014.

Rosen, S., Jörgensen, T., Hammersland-White, D and Holst, J.C. 2013. DeepVision: a stereo camera system provides highly accurate counts and lengths of fish passing inside a trawl. Canadian Journal of Fisheries and Aquatic Sciences, 2013, 70(10): 1456–1467.

Contact: Arill Engås (arill.engaas@imr.no).

Monitoring net volume during commercial purse seining

The volume for eight separate purse-seine sets was monitored during hauling (5 to 80% hauled net) using an omnidirectional fishery sonar to image the net and hence create three-dimensional representations of the net. An acoustic positioning system with transponders mounted in the net walls was used to monitor the location of various parts of the purse-seine and to validate the sonar-based net borders. Available space for fish in the caught shoal and how the space reduced during hauling was estimated by dividing catch biomass with the available net volume. The studies are a first step towards developing a method to study crowding densities in the net and for the development of real-time net monitoring methodology. Data on fish densities in the net can be helpful when determining limits for how late slipping can be allowed during hauling while net monitoring and an improved understanding of net shape and volume have the potential to contribute to improved fishing efficiency and catch quality. Contact: Maria Tenningen (maria.tenningen@imr.no).

Progress in the development of a Pelagic Survey Trawl –Multpelt 832

The Multpelt 832 pelagic survey trawl designed in cooperation with gear technologist, commercial trawl designers and researchers responsible for pelagic surveys was used in the IESSNS survey by vessels from Norway, Iceland and Faroe Islands to estimate of the mackerel stock in the North Atlantic in 2013. Prior to the survey gear technologists from IMR were involved in fine-tuning of the rigging and operation of the Multpelt trawl. The trawls used by the two Norwegian survey vessels were equipped with a fish escape preventer in the frontal part of the codend. Behaviour of mackerel and herring during trawling with the headline at the surface were observed with Go-Pro action cameras. These observations included documentation of the effect of a fish escape preventer during haul back. Mackerel were documented swimming for several minutes in the aft trawl belly at 5 knots towing speed. The time it took for mackerel to pass through the 200 m long trawl belly was estimated to be in the order of 8 minutes. During haul back of the sweeps and the trawl the forward trawl movement was slowed and mackerel were observed to swim forward inside the trawl. Fish that had passed the fish escape preventer were, however, trapped in the codend. The fish escape preventer is considered to be a useful tool in a survey trawl and should be considered for wider applications. The trawling methodology was approved as a method for mackerel assessment by WKPELA in February 2014. Contacts: John Willy Valdemarsen (john.willy.valdemarsen@imr.no), Shale Rosen (shale.rosen@imr.no).

CRISP

In its third year (started 1 April 2011) the Centre of Research-based Innovation in Sustainable fish capture and Processing technology hosted by the Institute of Marine Research in Bergen Norway has been working on multiple projects together with several industry partners, related to development of fishing instrumentation, low impact trawl gears, behaviour studies during trawling and a method to map spatial distribution of fish in the sea. The centre's activities and some results are described below. Contact: John Willy Valdemarsen (john.willy.valdemarsen@imr.no).

Pre-catch identification

The development of acoustic instruments for identification of species, quantity and fish size in schools has been one of the focus areas of CRISP since the start. This research is

done by Kongsberg Maritime, Simrad in close cooperation with Institute of Marine Research, Bergen. A new and improved fishery sonar, which can quantify the size of a school prior to shooting the purse seine, is currently being developed. This includes development and testing of new sonar data formats, and also the development of a standard calibration procedure for fishery sonars. A new side-looking fishery sonar for school inspections both before catching and school inspections inside the closed seine, has been developed by Simrad, and enters the trial phase onboard fishing vessels from 2014. In order to estimate fish size and species composition inside schools, the main activity has been to finalize calibration methods of wideband echosounders, and of the development of a new transducer with a sharper beam and to determine how this can be arranged in side-view mode. Measurements of single-fish at the border of a herring school have been done with good resolution. Contact: Egil Ona (egil.ona@imr.no).

Monitoring of fish behaviour and gear performance

Kongsberg Maritime AS, Simrad, has developed an integrated information system for underwater video, trawl sonar and echosounder information sent through a standard net-sounder cable from the trawl to the bridge. These instruments give in situ information about species and size of fish entering the trawl as well as monitoring the performance of the trawl. In addition a new trawl door sensor has been developed. This enables precise positioning of the doors in relation to the seabed. A major activity in 2013 has been to commercialize the products by designing a robust and easy-to-handle system for both commercial and scientific use. In addition, the integrated information system was further developed to include two modified echosounders (EK15) that were used to observe fish entering and passing back to the codend. This MultiSensor system has been tested to measure the height, pitch/ roll and spread of the trawl doors, and also a new interface (TVI) was tested to display the door measurements.

IMR cooperates with Kongsberg Maritime, Simard to develop instruments and to improve the communication between the trawl and the vessel using a standard sounder cable for transfer of video and acoustic data to the vessel. Contact: Arill Engås (arill.engaas@imr.no).

Deep Vision Technology

The DeepVision in-trawl camera system, which identifies and measures fish passing inside a trawl, was further developed in 2013 and was used in conjunction with a demersal trawl during a research cruise with RV "G.O. Sars" in April 2013 (previous deployments had been in pelagic trawls). Use of Deep Vision allowed other behaviour and gear investigations to be carried out with an open codend, preventing the catch of multiple tonnes of fish during just this one cruise. The system proved robust, and collected images of sufficient quality to identify species and measure lengths even during periods with high amounts of suspended sediments. Overall, fewer than 1% of images proved unusable due to poor visibility. Deep Vision software development focused on automating tasks in order to reduce analysis time. Contact: Shale Rosen (shale.rosen@imr.no).

Catch regulation in trawls

Currently, the catch rates of gadoids in the Barents Sea are often higher than wanted, and a system for dynamic catch control is required. A number of systems have been tested in CRISP. The simplest system, called the Excess Fish Exclusion Device (ExFED), use passive techniques where surplus fish are mechanically guided out of the trawl.

The ExFED consists of a fish lock just behind a rectangular opening in the upper trawl panel covered by a mat attached only at its leading edge. A fish lock prevents the targeted quantity of fish from escaping during haul back. From 1st January 2014 the Norwegian cod trawler fleet is allowed to use the ExFED combined with a selection grid during fishing. Contact: Arill Engås (arill.engaas@imr.no).

Low impact trawling

The development of low impact trawling technology has included work by Kongsberg Maritime, Simrad to use their acoustic communication cNODE system to control opening and closing of hatches in manoeuvrable trawl doors developed by the Egersund Group, and capture evaluation of a trawl with doors lifted 10 m off bottom compared with doors having bottom contact. A new design of a groundgear having less contact and pressure on the bottom substrate was developed by the Egersund Group, and was prototype tested onboard the research vessel G.O Sars in 2013 and 2014. A controlled opening and closing of both upper hatches in the SeaFlex doors were achieved. Catch comparison indicated reduced catch efficiency of the trawl when trawl doors were lifted off bottom that was partly explained by lower fish density than during comparable experiments in 2012. The tests with the new groundgear taught us that a mixture of bobbins rollers having bottom contact and with less diameter rubber spacers between the bobbins might be a gear concept that is catch efficient and has an acceptable trawl protection. Fishing trials with a pelagic trawl in the 2014 survey with G.O. Sars also resulted in high catch rates of cod while towing off bottom. Contact: John Willy Valdemarsen (john.willy.valdemarsen @imr.no).

12.9.2 University of Tromsø

Trials with the Newfoundland cod pot compared to the Norwegian 2-chamber pot and gillnets

Over a period of 2 years, we compared the Newfoundland cod pot (NF pot) to Norwegian 2 chamber pots and gillnets. The results show that the larger and rigid Newfoundland pots do not match catches with the Norwegian 2-chamber pots on target species cod (*Gadus morhua*).

Furthermore, the design of the pot is seen as impractical for the smaller vessels when large numbers (>20) of pots should be handled in fleets. None of the pot types caught more cod than gillnets. Due to mesh size in the NF pot larger fish were retained compared to the Norwegian design.

In areas with water currents up to 1 knot, gillnets and the Norwegian pots caught several cod, whereas the NF pot usually caught close to 0 fish. Contrary, in areas with extremely low water current, the results were opposite. In one case one NF cod pot caught more than 100 cod (3–5 kg) during a 24-hour set and subsequently almost 48 cod in a 3 hour set.

The results will be presented in MSc thesis June 2014. Contact: Roger B. Larsen (roger.larsen@uit.no).

Trials with modified hook attachment in the mechanized longline fishery

From the northern coastal longline fishery, it is reported that swivel between the hook and the gangion (snood) increase the capture of large fish. Fishers from the deep-sea fleets (large autoline vessels) caught interest in the idea and two cruises were organized along the banks in the Barents Sea. During May and December 2013 we collected data

from 2 commercial vessels (51 and 52 m) in an ordinary fishery for target species cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*).

Dataseries with the test-setup (hook with swivel) were compared to the ordinary hook attachment. By numbers, no significant differences between the setups were recorded. In the latter cruise we also measured all fish by length and weight on the test-lines. Again no significant differences were measured.

The results will be presented in MSc thesis June 2014. Contact: Roger B. Larsen (roger.larsen@uit.no).

Selectivity trials with grids and square mesh windows

The use of square mesh panels in the aft end of bottom trawls has been tested in several EU fisheries without clear or encouraging results. We compared the selectivity properties between a Norwgian bycatch reducing device for shrimp trawls (i.e. a Nordmöre grid with 19 mm bar spacing) and 120 mm square mesh panel in the aft end of the trawl funnel. Our results with the square mesh panel were furthermore compared to effects achieved in a Spanish trawl fishery off the coast of the Bay of Biscay.

For target species like cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and American plaice (*Hippoglossoides platessoides),* the Nordmöre grid removed almost all fish larger than ca. 20 cm, revealing clear size selectivity. Almost no fish (no matter the sizes) escaped through the square mesh panel. The discouraging results with the square mesh panel were also recorded in the Spanish trials.

The results will be presented in MSc thesis June 2014. Contact: Roger B. Larsen (roger.larsen@uit.no).

Observations of 3 different types of groundropes in fish trawls

During several bottom trawl cruises we tested bottom contact of various groundropes and observed fish reactions in the vicinity of them. To reduce bottom impact and fuel consumption a plastic semi-disc gear was attached to the trawl. This rig is easy to use, has half the weight of a comparable traditional rubber-disc rock-hopper and function well. With too little weight on this rig, the escapement under this groundrope increases dramatically.

A new version of rock-hopper with rolling discs was also tested. This rig has more or less the same weight as a traditional rock-hopper, but the drag during operation is reduced. We observed some fish (mainly cod) escaping under the gear, i.e. more or less as seen with the traditional rock-hopper gear.

Our aim is to continue to test the various types of groundropes with focus on bottom contact (impact); reduced fuel consumption and fish behaviour (i.e. reduce the number of escapees below the fishing line/groundrope). Contact: Roger B. Larsen (roger.larsen@uit.no).

Trolling for Gadoid fish species

A MSc student is currently working on a trolling system for cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and saithe (*Pollachius virens*). The rig is a modified version of trolling systems used for mackerels. So far most of the effort has been aimed at finding a design that is practical for smaller vessels (10–15 m). Initial fishing trials show encouraging results, but more data are needed to draw a conclusion. Contact: Roger B. Larsen (roger.larsen@uit.no).

12.9.3 SINTEF

Development of Trawl simulation software (CATS 2)

The objective of this project is to update the simulation software CATS which was made in the mid 90ties to a new version where more fishing gears can be analysed. The updated software can be used for analysis of trawls and seines with diamond, hexagonal meshes and or nets incorporating square mesh sections. The software can handle a number of different operations like trawling in either single or multi trawl configurations. The updated software will also be able to handle the seining process of a Danish Seine. Contact: Kurt Hansen (kurt.hansen@sintef.no).

Semicircular spreading gear

A new bottom trawl gear consisting of semicircular HDPE sections, "Semi-circle spreading gear" - SCSG provides approx. 9% more spreading than a rock-hopper gear. Tank experiments and video filming has shown that SCSG is very stable while towing, and that it is not sensitive to variations in the rigging or changes in trawl geometry, i.e. it does not "dig" or "fly" as earlier prototypes of the self-spreading groundgear have tended to. In addition, the semicircle-shaped profiles of the SCSG slide easily over the bottom and goes easily over rocks, etc. Preliminary results from the cruises performed in 2013 and 2014 suggest that the SCSG fish as well as, or better than the rock-hopper gear. This is because of less space between the semi-circle sections that not allow fish passing through them. Feedback from the fishers who have been involved in the fishing trails that the new gear is much easier to work with on deck. The new gear has thus great practical and commercial potential, and further development will focus on material choice to reduce wear. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Development of catch control device for trawls

This project is aimed at developing prototypes of catch control devices that could help controlling the size of the catch and that gently release the excess of fish at the same fishing depth. So long several prototypes have been developed and tested at sea giving encouraging good results. Still, the main challenge is related to the combine use with mandatory sorting grid sections that reduce water flow in the trawl and causes that fish does not falls back to the codend. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Water flow assessment of sorting grids

Water flow measurements were performed in 2 and 4-panel sorting grids, with and without lifting panels. The 4-panel sorting grid without lifting panel performed best since it reduced less water flow than the other grid sections and had the biggest cross section. Contacts: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no), Svein Helge Gjøsund (Svein.H.Gjosund@sintef.no).

Development of multirig semi-pelagic trawling

This project is aimed at increasing energy efficiency in the Northern shrimp fishery and the northeast Arctic cod fishery. So long this project has focused on: i) developing a gear control system mainly via enhanced winch control and vessel manoeuvring control; ii) developing a new self-spreading groundgears that reduces the escape of fish under the gear; iii) quantifying the differences in catchability and energy consumption

between bottom trawling and semi-pelagic trawling. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Semi-pelagic coastal shrimp trawling

This project is aimed at increasing energy efficiency and reduces fish bycatch in the coastal shrimp fishery in Northern Norway. By using a set of 2.5m2 semi pelagic trawl door instead of a 3m2 bottom trawl doors we obtained approx. 9% energy reduction. The catches of shrimp and bycatch were too small to give a conclusion based on them. Further experiments are planned to be carried out in 2014. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Catch control device for seine nets

A prototype for controlling the size of the catch in seine operations has been of tested in April 2014. Results showed that it effectively limited the catch to the predefined volumes: 4, 7 or 10 tons. Most of the fish escape happened during the retrieving process. Contact: Jørgen Vollstad (Jørgen.Vollstad@sintef.no).

The effect of lifting panel on grid-based selectivity

A sorting grid section, with a combination of a grid, a lifting panel and guiding panel, potentially reduce the water flow, and can provoke that fish start to accumulate in front of the grid. Small-scale tests measured the reduction in water flow, and fishing trials carried out under commercial conditions showed that the lifting panel had in fact a significant effect on the parameter "grid contact" (Cgrid; the probability that a fish comes into contact with grid), thus on the selectivity of cod. The presence of the lifting panel increased the contact probability by 16%, and when compared with a grid section without lifting panel (Cgrid = 0.66) there was an improvement of 24%. At catch rates of approx. 20 tons per tow hour, the 24% improvement in grid contact represent many thousand small cod been sorted out of the trawl. Contact: Eduardo Grimaldo (Eduardo.Grimaldo@sintef.no).

Random pairing as an approach to measure selectivity in commercial-like trawl fisheries

Trawls are one of the most widely used fishing gears around the world because of their flexibility and capacity to adapt to almost any fishery, type of seabed and weather conditions. The limitations and challenges often encountered by the scientists when working at sea have had as consequence the development of different sampling methods. In fisheries where the covered codend method cannot be used and the paired gear method cannot be applied, the so-called alternate haul method is often used. The study of selectivity in big pelagic trawlers is among the most challenging within trawl selectivity studies. The fact that the catches in these types of vessels are often big (>30 tons) have implications on the use of the covered codend method and the paired gear method. Converting the gear from a control to a test gear (necessary to apply the alternate haul method) and the steaming required carrying out the control and the test hauls parallel, can become time consuming processes that commercial vessels cannot afford. Consequently, a bulk of control hauls are often first collected followed by a bulk of test hauls, which later need to be paired. In trials carried out in this manner the amount of collected control hauls do not always match the amount of collected test hauls (unbalanced hauls) and in this situation, there is a tendency for the hauls that cannot be paired to be discarded. Practical limitations often lead to analytical challenges and the data

collected in this way often need to be analysed as pooled hauls (all control hauls and test hauls are pooled separately and then analysed as a single haul) or as individual hauls where the first collected control is "artificially" paired with the first test haul, the second control is again "artificially" paired with the second test, etc. Both of these procedures have analytical deficiencies mainly linked to the estimation of the confidence limits of the mean selectivity estimate values. This investigation is a selectivity study where the performance of a sorting grid system, a T90 codend and a codend with EW is compared using the alternate haul method in the Norwegian pelagic trawl cod fishery. The work proposes a method to cope with some of the challenges of running selectivity studies using the alternate haul method in trawl fisheries in general and pelagic trawl fisheries in particular. The method of random haul pairing presented i) overcomes the problems of having with unbalanced control and test hauls and ii) deals with the challenge of confidence interval underestimation. Contacts: Manu Sistiaga (manu.sistiaga@sintef.no), Bent Herrmann (Bent.Herrmann@sintef.no), Eduardo Grimaldo (eduardo.grimaldo@sintef.no).

Danish seine: Computer based design and operation

The main objective of this project is to develop two software tools for Danish seine fishing that ease future transition to the environmentally friendly Danish seine fishing method and that will support development of more optimized gear designs:

- A tool that enables the skipper to simulate the behaviour of the gear with different riggings and different operation procedure.
- A tool that enables the netmaker to create new net designs and evaluate their performance through simulations.

The project will run for three years (2013–2015). The research work will be divided between development of simulation models, development of software tools and verification of tools and models. The research team will be mainly SINTEF Fisheries and Aquaculture (SFH) and the University of Tromsø. However, additional international expertise will be provided through an expert workshop. Industry will be involved through workshops. Contact: Bent Herrmann (Bent.Herrmann@sintef.no).

Understanding sorting grid and codend size selectivity of Greenland halibut (*Reinhardtius hippoglossoides*)

Based on a collaboration with the University in Tromsø (Norway) have SINTEF Fisheries and Aquaculture been involved in a study to understand the size selectivity of Greenland halibut in trawls. A scientific paper has been published in Fisheries Research. Contacts: Bent Herrmann (Bent.Herrmann@sintef.no), Roger B. Larsen (roger.larsen@uit.no).

A comparative analysis of legislated and modified Baltic Sea trawlcodends for simultaneously improving the size selection of cod (*Gadus morhua*) and plaice (*Pleuronectes platessa*)

Based on a collaboration with Thünen-Institute of Baltic Sea Fisheries (Germany) and DTU AQUA (Denmark) have SINTEF Fisheries and Aquaculture been involved in a study on simultaneously improving size selectivity of cod and plaice in codends for Baltic sea. A scientific paper has been published in Fisheries Research. Contacts: Daniel Stepputtis (daniel.stepputtis@ti.bund.de), Bent Herrmann (Bent.Herrmann@sintef.no), Jpfe@aqua.dtu.dk .

Predictive models and comparison of the selectivity of standard (T0) and turned mesh (T90) codends for three species in the Eastern Mediterranean

In collaboration with Ege University (Turkey), Cukurova University (Turkey) and in connection With ICES SGTCOD have SINTEF Fisheries and Aquaculture been involved in a study on the effect of using T90 codends as alternatives for traditional diamond mesh codends (T0) for the size selection of Mediterranean species. A scientific paper has been published in Fisheries Research. Contacts: adnan.tokac@ege.edu.tr, Bent Herrmann (Bent.Herrmann@sintef.no), gokhan.gokce@ymail.com .

Understanding the release efficiency of Atlantic cod (*Gadus morhua*) from trawls with a square mesh panel: effect of panel area, panel position, and stimulation of escape response

Based on a collaboration with Thünen-Institute of Baltic Sea Fisheries (Germany) and DTU AQUA (Denmark) have SINTEF Fisheries and Aquaculture been involved in a study on the release efficiency of cod through square mesh panels in trawls. A manuscript has been submitted to a scientific journal. Contacts: Bent Herrmann (Bent.Herrmann@sintef.no), Daniel Stepputtis (daniel.stepputtis@ti.bund.de), Juka@aqua.dtu.dk .

Effect of lifting the sweeps on bottom trawling catch efficiency: A study based on the Northeast arctic cod (*Gadus morhua*) trawl fishery

Fuel consumption and environmental concerns have led bottom trawlers fishing for cod (*Gadus morhua*) in the Barents Sea to use semi-pelagic doors. However, this change may affect fish herding and consequently the catch efficiency of the gear. In this study, we compared the catch efficiency of two different setups where the sweep length with bottom contact was different. This setup also enabled us to estimate the herding efficiency of the sweeps on the seabed. The data for this study were collected using the alternate haul method and analysed using a new method for unpaired data. We estimated that the setup with the lifted sweeps captured on average 33% fewer cod than the setup that kept the sweeps at the seabed. The loss of catch for cod was length independent and significant for a length span between 41 and 104 cm. When sweeps were lifted above the seabed, herding was negatively impacted and fish were lost; in contrast, when on the seabed, the sweeps were able to herd (on average) 45% of the cod into the catch zone of the gear. Lifting the trawl doors from the seabed is touted as a positive development for this fishery. However, our results show that lifting the doors and consequently the sweeps can lead to substantial catch losses. Thus, this study highlights the importance of carefully evaluating the positive and negative potential consequences of introducing changes in a fishing gear. Contacts: Manu Sistiaga (manu.sistiaga@sintef.no), Bent Herrmann (Bent.Herrmann@sintef.no), Eduardo Grimaldo (eduardo.grimaldo@sintef.no).

Estimating the selectivity of unpaired trawl data: a case study with a pelagic gear

Most selectivity experiments either employ the covered codend or paired gear methods. It is not always possible, however, to use these methods. Owing to operational, biological and/or environmental considerations, there may be no obvious way or it may be inappropriate to pair the test and control data. Hence, it will not be possible to estimate the selectivity of the gear and its uncertainty using standard statistical methods.

This study presents a methodology to analyse the selectivity of fishing gears from un-paired test and control data. The uncertainty in the control and test population structures is accounted for by using a double bootstrapping procedure that takes into account both between-haul and within-haul variation.

This bootstrapping approach is used to assess the selectivity of two different devices: a 139.5 mm T90 codend; and a 135.9 mm codend with 140.9 mm lateral Exit window, in the Barents Sea pelagic cod trawl fishery. The purpose of the experiment was to test and compare the performance of the two devices in pelagic trawl fisheries, where high densities of fish can be encountered. Significant differences were detected between the T90 codend and the codend with the Exit Windows but only for sizes of cod between 55 and 76 cm. Contacts: Manu Sistiaga (manu.sistiaga@sintef.no), Bent Herrmann (Bent.Herrmann@sintef.no), Eduardo Grimaldo (eduardo.grimaldo@sintef.no).

12.10 NETHERLANDS

12.10.1   IMARES/ILVO

Project: ICES research on pulse trawling

Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Dick de Haan (dick.dehaan@wur.nl)

The publication of the catch comparison of 2011 in in Fisheries Research came out with reference: *van Marlen, B., Wiegerinck, J.A.M., van Os-Koomen, E., van Barneveld, E., 2014. Catch comparison of flatfish pulse trawls and a tickler chain beam trawl. Fisheries Research 151, 57–69*. IMARES made new reference field strength measurements on-board the commercial pulse trawler TH7 in April 2014 with gears laid on the bottom. Tests were planned on dab under electrical stimulation to study the effect on skin damage.

SGELECTRA met in Ostend, Belgium in October 2013 and will continue its work over 2014–2016 under the new name WGELECTRA. Reports are on the ICES website (www.ices.dk).

Project: Pulse trawling monitoring program

Contact: Mascha Rasenberg (mascha.rasenberg@wur.nl)

IMARES commenced a pulse trawling monitoring programme from December 2011 until March 2013. The objective of this programme was to get more insight in the catch composition of the pulse trawling fleet, which aims at catching flatfish. The project exists of two programmes; an independent observer programme and a self-sampling programme. In the observer programme, ten observer trips have been carried out by IMARES and ILVO in 2012. The observers followed the standard discard protocol, which is also used for trips for the EU Data Collection Framework. In the self-sampling programme, 25 vessels have collected data on their catch according to a standard protocol during the period December 2011-March 2013. Analysis of the collected data were carried out in May-September 2013. The report was published in November 2013 and came out with reference: *Rasenberg, M., Van Overzee, H., Quirijns, F., Warmerdam, M., Van Os, B., Rink, G. 2013. Monitoring catches in de pulse fishery. IJmuiden. IMARES report C122/13*. The results show that on average 30% of the catch consists of landings, mainly sole and plaice. The discard percentage varies between 17% in the self-sampling program and 29% in the observer program. The rest of the catch (more than 40%) consists of benthos and debris. The self-sampling data show that 1/3 of these catches consists of benthos. The average amount of plaice caught in the pulse fishery (both self-sampling

and observer) is lower compared with the beam trawl fishery. The average sole catches are higher in the pulse fishery, however the discard percentage of sole is lower in the pulse fishery compared with the beam trawl fishery.

Recently, the Dutch ministry of Economic Affairs started a new pilot project to ease the implementation of the landing obligation. The pulse gear has proven to catch less discards and could help fishers with the implementation of the discard ban. Therefore, the Dutch ministry doubled the amount of pulse permits and started a pilot project to research the selectivity of the pulse trawl. The exact aim and methods are still to be determined.

Project: VIP Skipper Network SumWing South

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

In the SumWing project constructional improvements were designed and tested to reduce structural damage. Some skippers changed to the integrated PulseWing system, in which SumWing and pulse trawling are combined. A problem remains that the lower front side of the wing and the runner show considerable abrasion due to bottom contact. The project was finished with the report in Dutch: *van Marlen, B., VandenBerghe, C., 2013. Praktijknetwerk SumWing Zuid. IMARES Report C125/13. p. 86*.

Project: VIP Skipper Network Discards South

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

A number of beam trawler skippers were interviewed to retrieve their knowledge and experience in reducing discards. IMARES did a short study on the effect on storing hatched sole in fish survival tanks (0.6x0.4x0.12m) both in the lab (control groups) as on FRV "Tridens" in December 2012. Groups of 50–55 individuals were used, with 5 fish per tank. No single fish died in all three groups. A survival experiment with hatched sole (< MLS; as control group) and undersized sole from catches (test group) was carried out in April and May 2013 from a commercial 2000 Hp pulse trawler (TX-43). Six underwater cages were filled in April with 15 sole (hatched, control) and 15 sole (caught, test group) each, placed on the bottom at 30 m depth and survival monitored for 48 h. The seawater temperature was low at ~ 7 °C. In addition undersized sole and plaice from the catch were stored in two large on-board tubs and survival monitored for 36–71 h. The survival of fish in the cages was low: 1.2% for the control fish and 14.4% for the test fish. The tub trials showed better survival some 60% for sole after 36 h, and 90% for plaice after 40 h, dropping to 80% after 71 h. The survival in test and control groups was low when using the cages, and the cause of death questionable (temperature shift, polluted water). In the second experiment six cages with filled with 15 undersized sole caught from the fish processing conveyor belt and 15 from the deck hoppers, and two stacks of nine on-board tanks each with three undersized sole caught from the conveyor belt and from the deck hoppers. Seawater temperature was ~ 11 °C. The observation time was 72 h. The survival rates were as follows: in the cages from the belt 61%, from the hoppers 63%; in the on-board tanks from the belt 70%, from the hoppers 56%. There was not enough data for statistical analysis of covariates.

A second series of trials took place on a smaller 300 hp vessel (TH-10) in July 2013. In the first experiment there were 17 cages filled with in total 324 undersized plaice, 150 sole, 16 turbot, 14 brill, 10 flounder, 3 dab and 1 lemon sole from the catches, and two large on-board storage tubs. The air temperature was relatively high at 22 °C, and seawater temperature was 17–18 °C, the cages were set at a depth of 20–30 m. The highest

survival was found for sole (27%, after 154 h) followed by plaice (11%, after 145 h). Survival was low for turbot, flounder and brill, while for the other species the numbers were very low for analysis.

In the second trial, the 17 cages were filled with 275 undersized sole and 199 plaice, in most cases 30 fish per cage. Now the survival was extremely low: 5% for sole after 204 h and 0% for plaice after 157 h. All fish were taken from the conveyor belt.

The circumstances differed greatly from the ones on the first vessel. This boat had less deck space, fewer people in the fish processing line, and there were higher air and seawater temperatures. The cage survival was low, which may have been caused by sand in codends, the higher temperatures. Often there were large numbers of starfish present in the cages, which may have eating fish remains.

The following plots show a comparison of survival for plaice (top) and sole (bottom) from several references (C = conventional beam trawl; P = pulse beam trawl; observation time 72 h, for TH-10 ~165 h). Both the conventional trawls in van Marlen *et al.*, 2005 and Revill *et al.*, 2013 gave a mean survival rate of 40% of the observed plaice, and sole. The data from van Beek *et al.*, 1990 showed lower values at 20%, and 15%. The mean values for the pulse trawls were higher 70% and 50%. The TH-10 data were lowest. These are preliminary findings, and need to be re-investigated with further experiments.
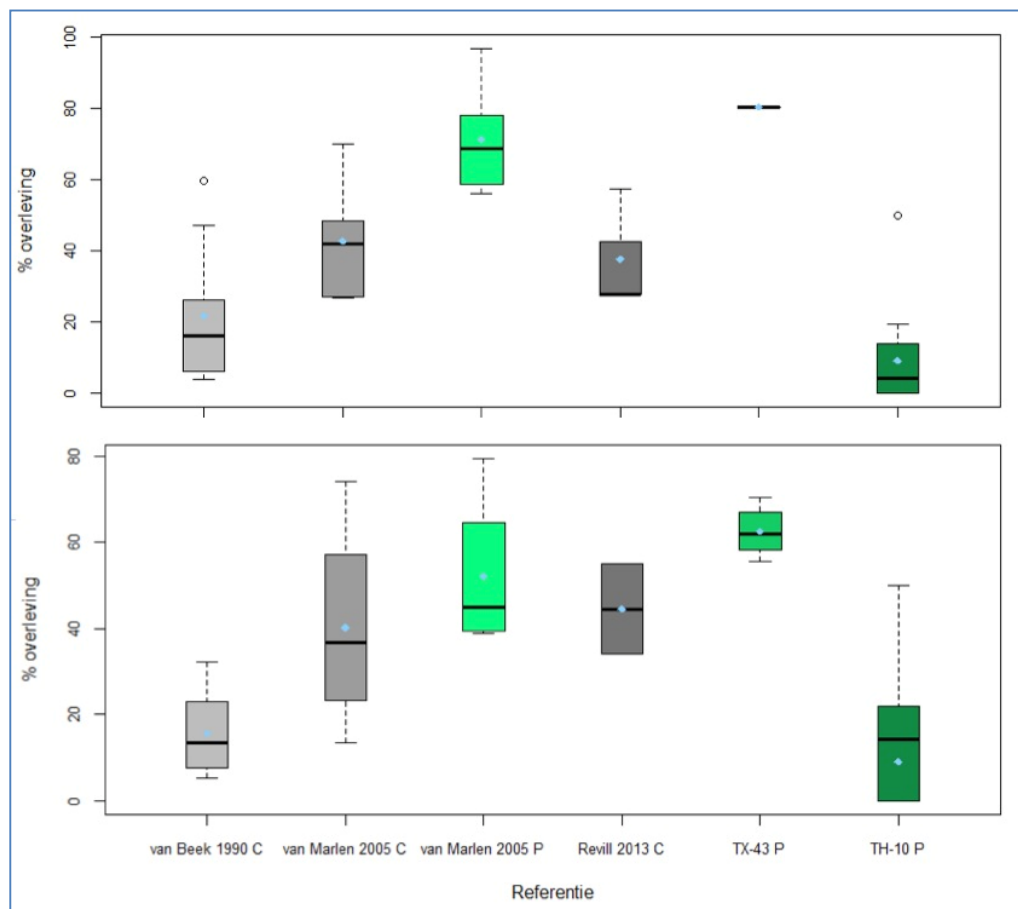
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Project: VIP Skipper Network Net Innovation South

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

The purpose is to address the problem of discarding by exchanging information on fishing gear and practices. A new square net was tested on the commercial vessel GO-31 (2000 Hp) using a SumWing with a higher runner to avoid abrasion. The gear showed unstable behaviour, which was not the case with a conventional round net.

A shorter net was tested vs. a standard net on the cutter GO-48 (2000 Hp) in November 2013 resulting in equal landings (p = 0.078) and fewer discard fish (ratio 65%, p = 0.003). Further tests are foreseen in 2014.
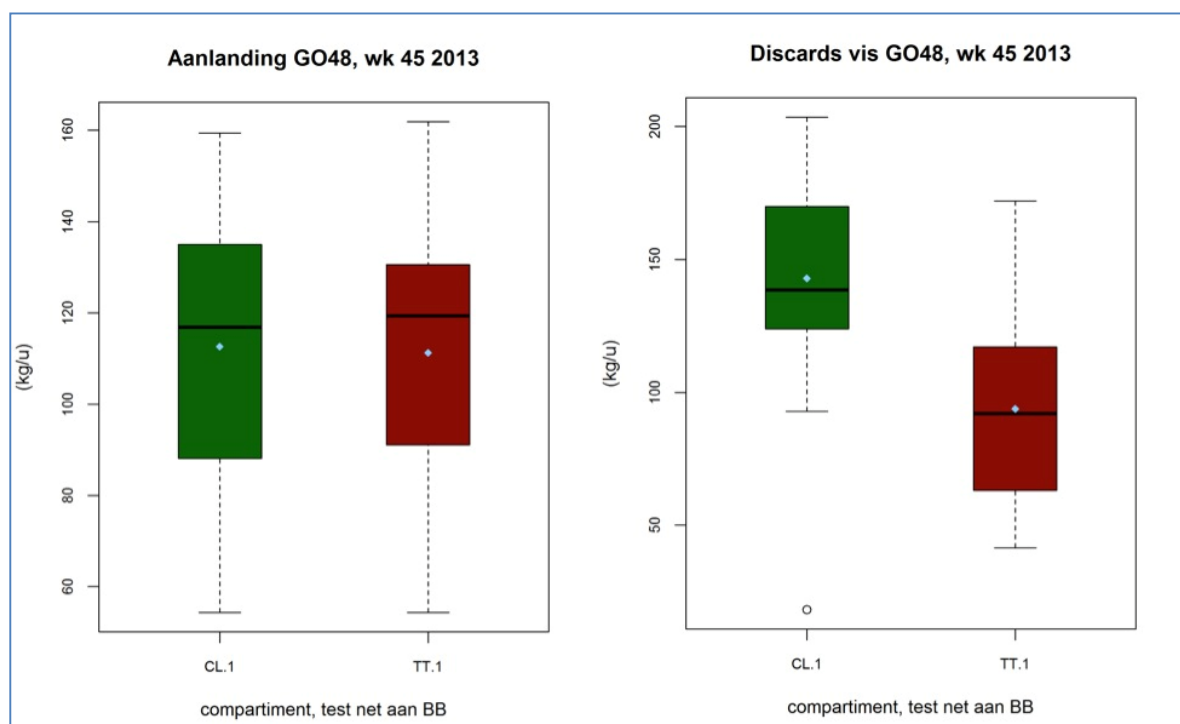
Trials with a new Polyvalent Wing were carried out on the TH-7 in December 2013 and January 2014 resulting in higher gross earnings and a somewhat lower fuel consumption for the new wing (ratio 86%).

Project: VIP T-Line

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

The T-Line concept is a trawl using pins instead of chains to chase fish out of the seabed. A first trial was done in December 2011 with T-Lines integrated in a SumWing, but the pins had a tendency to break off and catches of particularly sole were not satisfactory. A new version was tested in 2012.

T-Line elements on a SumWing (left) and detailed (right).

A simulation was made in DynamiT™ on the net with two codends. The SumWing effect was simulated with a weight in front of the wing. ILVO made underwater observations of the gear in January and July 2012. Further trials are scheduled in 2014 on a new version of the gear with the T-Lines underneath the SumWing and an array of light tickler chains behind but depend on the fishery.

Project: VIP HydroRig–II

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

The first project was rounded off with a final report in 2011. A follow-up project started in 2013. A new model HydroRig-II was designed and built and will be tested in 2014.

Project: VIP Fishing with low impact twin-trawl

Contact: Floor Quirijns (floor.quirijns@wur.nl)

A catch comparison of 13 hauls was done in October 2013 on two vessels from the Ekofish Group, one with a twin-rig with the otterboards flying above the seabed and elevated sweeps by adding bobbins (balls) and lighter Dyneema warps (PD-43), and one with a conventional twin-rig (PD-147). The total landings were equal, significantly less benthic invertebrates were caught (44% in numbers; $p = 0.01$), and there was no difference in the quantity of discard fish. The project is reported in: *Quirijns, F.J., Machiels, M.A.M., de Vries, M., Wiegerinck, J.A.M., 2013. 'Vistuig met ballen': Vergelijkend onderzoek vangstsamenstelling aangepast twinrigtuig (In Dutch). IMARES Report C063/14, p. 28.*
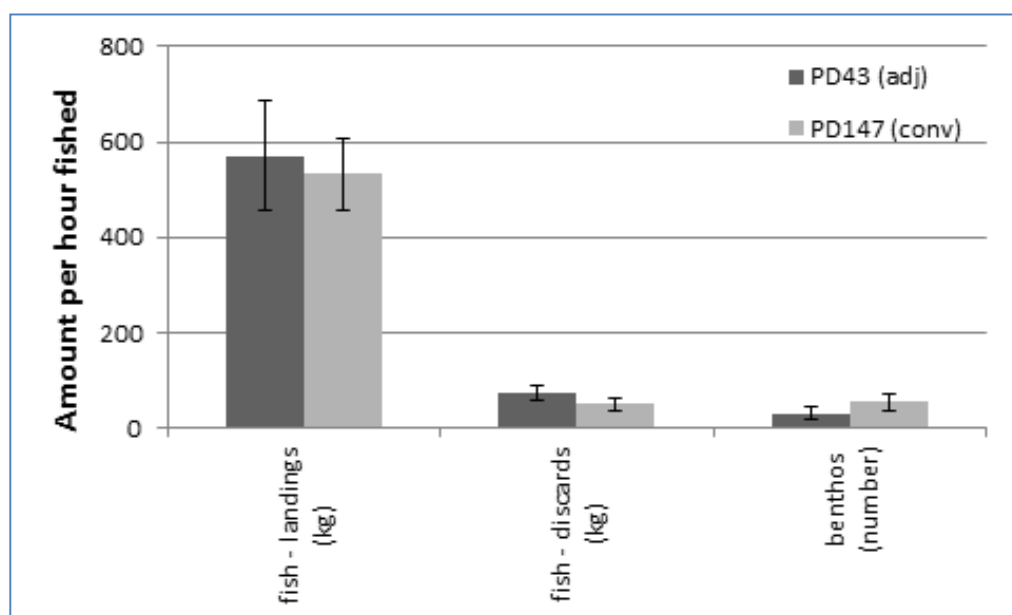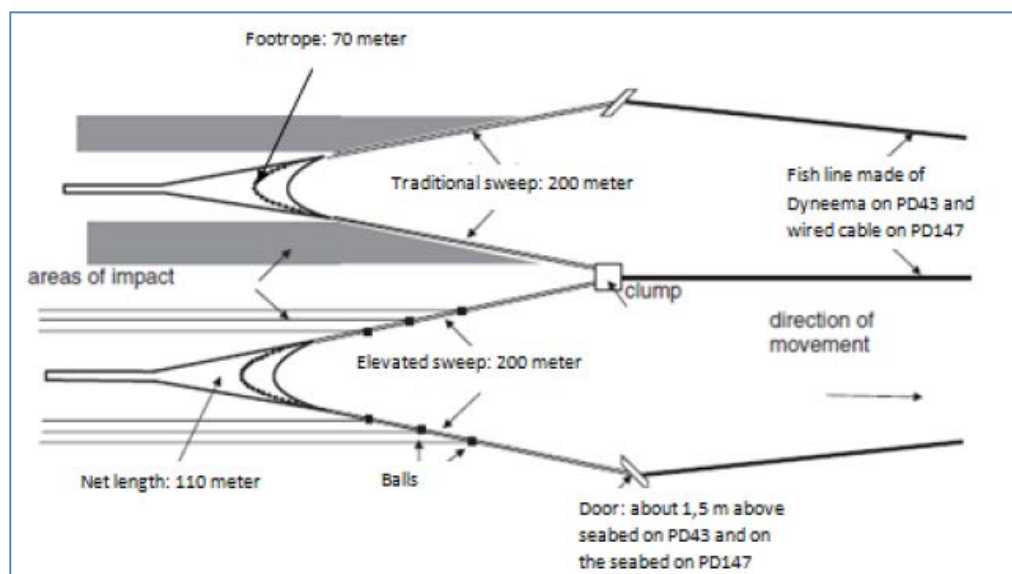
Project: VIP VDTN Bycatch Reduction by Technical Means

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

A series of trials on a horizontal separator panel (50 mm mesh size) and an escape window in the top sheet (160–200 mm mesh size) with a benthos release hole in the lower part were done on FRV "Tridens", with skippers of the two participating 2000 Hp commercial beam trawlers (TX-68 and UK-45). This work was done in cooperation with ILVO of Ostend, Belgium. Most fish seem to end up in the lower codend and the configuration resulted in 35% fewer undersized fish and benthos. Further trials on the two commercial boats vessels were done in 2013. These experiments showed that landings can be maintained at the same level and fish discards be reduced with 15% (TX-68) to 26% (UK-45), and benthos bycatch with ~50% when applying a benthos release

hole in the lower part. Further experimentation and fine-tuning was recommended. The project is reported *in*: *van Marlen, B., Bol, R., Groeneveld, K., Nijman, R., Rink, G., Buyvoets, E., 2013. Vermindering discards door technische aanpassingen in de netten (VIP - VDTN). IMARES Report C127/13 (in Dutch). p. 52.*

Project: VIP VVE

Contact: Bob van Marlen (bob.vanmarlen@wur.nl); Sascha Fässler (sascha.fassler @wur.nl) and Sven Gastauer (sven.gastauer @wur.nl).

This project with the pelagic fishing industry in the Netherlands aims at reducing discards of boarfish by improving species identification though echosounder information. The fishing vessel SCH-6 "Alida" is operating four acoustic frequencies (38, 70, 120, and 200 kHz) and collected multifrequency acoustic data on a fishing trip in the Western Channel. The echosounder on the vessel was calibrated and echograms were analysed. A multifrequency species identification algorithm was developed using the LSSS software developed by Marec (Norway). The colouring of echograms of boarfish as shown below enables a quicker identification on-board. The project will end in June 2014.
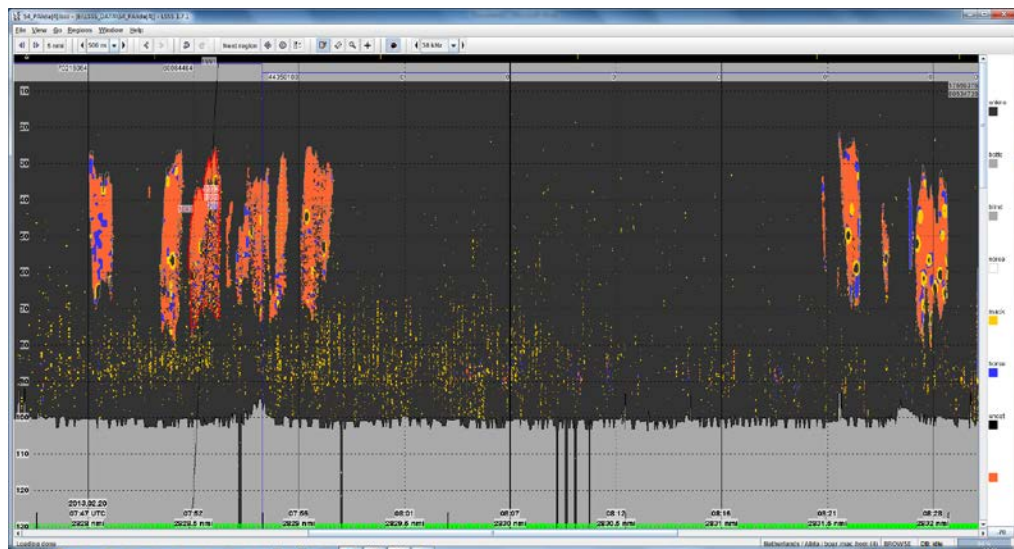
Project: Pilot Landing Obligation Pelagic Fleet

Contact: Bob van Marlen (bob.vanmarlen@wur.nl); Martin Pastoors (martin.pastoors@wur.nl)

The new EU obligation to land all catches of regulated species will apply to the pelagic fisheries from 1 January 2015 onwards. Although the pelagic fisheries are generally described as single species fisheries with relatively lower bycatch rates, the new regulation still posed a number of specific challenges that need to be addressed prior to the implementation of the regulation.

In the first half of 2013, the Pelagic Freezer-trawler Association (PFA) already recognized the need to prepare well for the new regulation although the regulation had not been formally agreed at that stage. The PFA initiated a pilot project to explore possible mitigation strategies to avoid unwanted bycatch, to handle and use unwanted bycatch and to find feasible strategies to document and control the catches. The results of the

pilot project would also inform discussions on the future technical measures regulations that impact on discards. The project started in August 2014 and finished in February 2014. IMARES was commissioned to lead the project with inputs from a consortium consisting of the fishing companies that are members to the PFA, the Dutch ministry of Economic Affairs, the Dutch inspection agency NVWA, Maritiem BV and Archipelago Marine Research. The project was funded by the PFA, who was partially compensated in the form of scientific quota.

The pilot project addressed four main objectives:

1) How to **avoid** catching unwanted fish?

2) How to **handle and use** the unwanted catch that is caught despite measures to avoid?

3) How to **document and control** the composition of the catches?

4) How does the current **technical measures** regulation affect discarding in PFA fisheries and how could new approaches to avoid, handle and use unwanted catches be accommodated in future technical measures regulations.

Although not a formal objective, the project also facilitated the collaboration between industry, research, regulators, control and service suppliers on the implementation of *the landing obligation.*

How to avoid catching unwanted fish?

In this pilot project, the focus has been on release panels made of (semi)-rigid flexible grids in the net that should allow unwanted fish of certain sizes to escape from the net. Two types of panels produced by Maritiem B.V. of Katwijk, the Netherlands, were tested: escape panels with fixed bars and escape panels on the basis of Dyneema netting. These escape panels have been tested in the herring fishery and to a lesser extent in the mackerel fishery during the months August to December 2013.

To assess the effects of the different sorting grids on the catch of a test vessel, information on length distribution per species per haul were compared with a reference vessel. In general there were no clearly distinct length compositions between the test vessel and the reference vessel for any of the trials or species. This indicates that release of smaller-sized fish was not effective for the tested grid modifications in autumn fisheries (for herring). During the last trip (for mackerel), an indication of a possible effect of the gear modifications could be derived from the higher average weight of the mackerel compared to the reference vessel. In general, the discard percentages encountered during the gear trials, did not differ from the range that was found in the regular discard sampling programme of the pelagic fishery that is carried out by IMARES. There were not sufficient comparative samples to allow for statistically significant results.

How to handle and use the unwanted catch that is caught despite mitigation measures?

A discard-collection and mincing device was placed on board of the SCH-81 "Carolien". It consisted of a discard stream from the sorting device, a separate conveyor belt that transported the discards into a water-cooled hold, from which they were transported again into the mincing device. The mincing device can operate up to a discard percentage of around 4% at a rate of xx kg h^{-1}. The mincing process did produce also irregular pieces, mostly tails.

The chemical analyses of discard samples showed that they are suitable for production of higher quality fishoil with protein as a by-product. The most economic valuable product valorisation should be analysed in a broader perspective.

How to document and control the composition of the catches?

A major challenge for the landing obligation will be to assess the composition of the retained bycatch of regulated species. Here the focus will be on the species and length compositions of the retained bycatch. The trial vessel that kept discards on board (SCH-81) was monitored using three different techniques:

- Scientific observer on board.
- Analysis of random samples taken from the discard fraction.
- Electronic Monitoring of the bycatch handling procedures.

In three out of four hauls that could be compared, there was an overall consistency between the different methods for the most abundant species. For one of the hauls, the composition of the discard samples differed considerably between the two methods used (random frozen samples and observing on board). The difference was between the proportions of mackerel in the sample that could be due to the timing of when samples were taken. Mackerel is known to sink to the bottom of the fish tanks, so taking a sample from the beginning of a fish tank discharge could give a different species composition compared to at the end of a tank discharge.

General Electronic Monitoring of a no-discard policy

To verify that no discarding took place on the trial vessel, Remote Electronic Monitoring (REM) equipment was installed by Archipelago Marine Research. The REM system consisted of 8 cameras and a recording device. One of the cameras was specifically aimed at monitoring the species and length composition of the retained bycatch (see above). The other seven cameras were aimed to verify the no-discard policy.

Overall, the camera system worked satisfactory after the initial technical hurdles were taken, but the process of coupling and uncoupling of the fish pump was difficult to observe.

How does the current technical measures regulation affect discarding in PFA fisheries and how could new approaches to avoid, handle and use unwanted catches be accommodated in future technical measures regulations?

The landing obligation constitutes a 180° change of the CFP. This means that the current set of technical measures legislation will have to be changed to allow for landing the catches that are now still obligatory to discard (e.g. Reg. 850/98, Reg. 1224/2009, Reg. 39/2013, Reg. 227/2013). One of the objectives of this pilot project was to establish which parts of the existing technical measures legislation should be adapted or removed. The most important technical measures that should be amended are the following:

- Article 4 (1) Reg. 850/98 and Annexes I to V
- Article 4 (2a) Reg. 850/98: one-net rule.
- Article 19 (1) Reg. 850/98: obligation to discard.
- Art. 19a (1) Reg. 227/2013: prohibition of highgrading.
- Article 42 Reg. 850/98: Processing operations.

- The Control regulation 1224/2009 and the Technical Measures regulation 850/1998 allow for the type of handling and processing on board of discards (unwanted bycatch and fish below Minimum Conservation Reference Size).

Reflections on the process

The pilot project on the landing obligation for pelagic fisheries resulted in an interactive process between fishing industry, research, fishery management, control authorities, technical suppliers and NGOs. The interaction meant that there was a joint learning process on what the landing obligation could mean in the practice of this fishery. Joint learning is important because of the many uncertainties surrounding the implementation of the landing obligation.
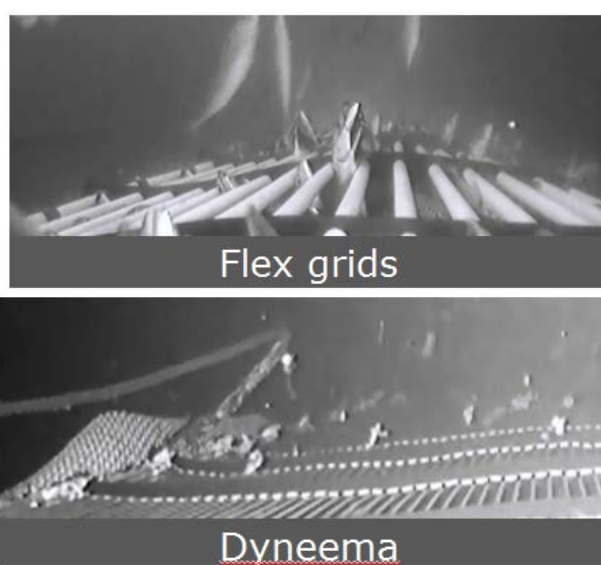
The figures above show the two types of escape panels tested (Source: Maritiem B.V., Katwijk, the Netherlands).

Project: VIP FishWing

Contact: Bob van Marlen (bob.vanmarlen@wur.nl)

A short trial was made with a new wing type called "FishWing" on the 300 hp MFV LT34 "Jupiter" in October 2013 compared with a conventional beam trawl. The experiments suffered from bad weather and mechanical breakdowns, and only a small number of hauls (7) could be monitored for catches and bycatches. This wings has a cross sectional shape with a sort of bulb on the suction side (lower edge) as can be seen in the figure below and was tested in a towing tank of the "Entwicklungszentrum für Schiffstechnik und Transportsysteme e. V.; DST – Development Centre for Ship Technology and Transport Systems" in Duisburg, Germany, showing that an increasing pressure drop at the bottom can indeed be generated as a function of increasing towing speed. Statistical analysis of the results showed that all fish discards lumped together ($p = 0.002$), plaice ($p = 0.015$) and sole ($p = 0.043$) landings were significantly less in number. The ratios between the FishWing and the conventional Beam trawl were respectively: 50.5%, 60.5%, and 71.6%. The FishWing was not easy in terms of handling. The project will stop at the end May 2014.
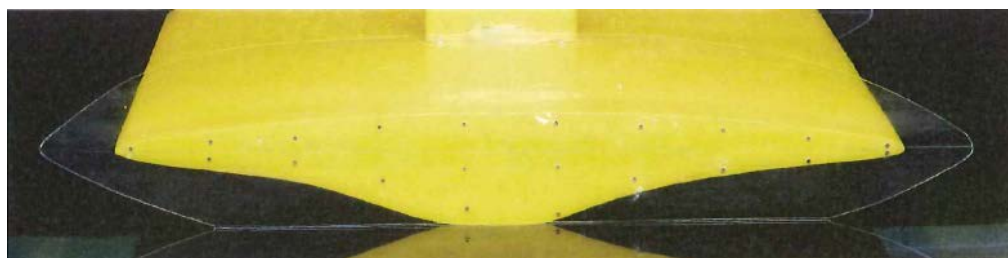
Project: VIP VRV

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This project was set-up with fishing company Geertruida B.V. (also involved in the HydroRig projects). The aim is to look at potential products that can be made of fish offal from gutting on-board and use a hydrolysis process with added enzymes to create higher valued products. Samples were taken from MFV and analysed by VFC/Lipromar of Cuxhaven (linked to Saria GmbH), Germany, and FBR of Wageningen, Netherlands. The result shows products such as: fishoil and fishmeal, but potentially also bioactive peptides with medical or functional food applications. Depending on the volume that can be generated and the price, that the fishers can get there may be economic incentives to use this material. The project is to be continued until the end of 2014.

12.11 JAPAN

JSFS Workshop on "Balanced harvesting *vs.* selective fishing" on September 2013

Is selective fishing a past ethic? – Considering the implication of an article published in "Science"

Background in Fishing Technology Research on the Science Paper	T. Arimoto
Implication of the Science paper on Balanced Harvesting	M.Makino
Genetic impacts of selective fishing on fishery populations	T. Kitakado
Ecosystem management that is feasible by selective fishing	H. Matsuda
Varied utilization among local ecosystem by coastal fisheries	T. Maruyama

JSFS Round Table Meeting on March 2014

Damage and loss on fisheries by sea mammals in Hokkaido, for aiming the harmonized symbiosis with wild lives

Fin-footed mammals - Migration and feeding habit	Y. Mitani
Steller's sea lion – Damage and loss on fisheries	O. Yamamura
Habour seal – Damage and loss on fisheries	M. Kobayashi
Fur seal - Damage and loss on fisheries	T. Horimoto
Requirement toward sustainable fisheries	S. Ohmoto
Stock management of wild lives	H. Matsuda
Gear improving for reducing damage and loss by sea mammals	Y. Fujimori

12.11.1   Hokkaido University

[Contact person: FUJIMORI, Yasuzumi <fujimori@fish.hokudai.ac.jp>]

Prevention of seal bycatch and fish damage in a set-net fishery along the east coast of Hokkaido, Japan

In the last decade, the interaction between fisheries and seal along the coast of Hokkaido has increased remarkably. We advancing the modification of fishing gear to reducing seal bycatch of a salmon set-net fishery in Erimo, Hokkaido. In a set-net, the actual condition of fish damage in the catch was investigated as that the averaged percentage of damage was 10.3% at morning and 2.2% at noon. The damage seemed to decrease with catch increases. Currently, the plan of gear modification is ongoing and will be experimented.

Effect of netting color of frame trawl for sampling juvenile Walleye pollock (*Theragra chalcogramma*)

The survey for juvenile Walleye pollock is carried out annually around the coast of Hokkaido, Japan by the fisheries research department of Hokkaido. In this survey, the frame trawl with 2m x 2m mouth and sky-blue netting is used regardless of area and vessel. We conducted the alternate fishing experiment using two kinds of netting, sky-blue and black, to improve catch performance of the frame trawl. The catch number of black netting was three times of that by sky-blue netting at night-time although there was no difference at daytime. In addition, at nighttime, the black netting shows the capability of catching larger size. We intend to compare the visibility of these netting by measuring underwater contrast.

Influence factor of catch in a survey of juvenile jack mackerel (*Trachurus japonicas*) in the Sea of Japan

The catch data of pelagic trawl survey in the Sea of Japan, conducted annually by fisheries experimental station in Tottori prefecture, was analysed statistically with GLM to know the most important factor among towing speed, trawl spread, towing depth, and survey area. As the result, the towing speed showed the notable effect to the catch. Hereafter, we will experiment to investigate the relationship between towing speeds and trawl geometry, then, consider the apt net plan and towing condition for this survey.

Solving the relationship between dynamic characteristics and flow condition around otter board using CFD (Computational Fluid Dynamics) techniques

CFD has capability of quantification for the relationship between dynamic characteristics and flow condition around otter-board and of reducing the cost and time for developing otter-board. We advancing the utilization of CFD for designing otter-board to aim at efficient development of new type of otter-board joining with Tokyo University of Marine Science and Technology. A part of the past result was presented in 11th International workshop of DEMaT held in Rostock, Germany, 2013 (Y. Takahashi *et al.*, http://www.demat.uni-rostock.de/2013/).

12.11.2   Fish Behaviour Section, Tokyo University of Marine Science and Technology

[Contact person: ARIMOTO, Takafumi<tarimoto@kaiyodai.ac.jp>]

Swimming performance of fish

Temperature and fatigue effect on the maximum swimming speed of jack mackerel was published (Riyanto *et al*. in Fisheries Science 80(1), p.53–59, 2014; http://link.springer.com/article/ 10.1007%2Fs12562–013–0686–6) for estimating the maximum swimming speed through the analysis of stride length and muscle contraction time. The follow-up research has been continued with ECG/EMG monitoring for understanding the swimming performance in relation to capture process of trawl gear.

Growth change of vision and swimming performance of bluefin tuna

For aiming the technical improvement of cage farming for artificially, hatched stock of bluefin tuna, swimming and schooling behaviour of larvae and juveniles was monitored in the keeping tank and cage, in order to identify growth change of the performance in relation with the vision and lateral line sense.

Fishing impact assessment of Japanese-type set-net, in Thailand

The impact of recently introduced set-net in Thailand has been examined with the long -term catch data, through the analysis of mean trophic level on catch sustainability, and the fuel consumption compared with other small-scale coastal fishing gears such as gillnet, crab trap and cuttlefish jigging. For confirming this trend as the index to analyse the fishing impact, the trophic level of catch species were newly examined compared with muscle tissues and stomach contents, sampled from set-net and other coastal gear on 2012–2013, and tested for carbon and nitrogen stable isotope analysis.

Capture process of squid jigging in relation to the new challenge of LED introduction

Squid response to light was analysed through the laboratory and onboard experiment, for understanding the capture process how squids are attracted in accordance with the underwater light intensity patterns. The practical introduction of LED was also ongoing for improving the attracting and jigging process.

12.11.3   Nagasaki University

[Contact person: MATSUSHITA, Yoshiki <yoshiki@nagasaki-u.ac.jp>]

Use of artificial light in a large-scale trapnet fishery

We developed a low power underwater lighting system for fish attraction in the trapnet fishing ground. A design of lighting system and its performance when set in the trapnet was published in *Nippon Suisan Gakkaishi* (Masuda *et al*., 2012; https://www.jstage.jst.go.jp/article/suisan/78/5/78_12–00017/_pdf). Fish behaviour against the lighting system is presented in the TG on "light" in this WGFTFB.

Survey on interaction/interference of light in light fisheries

Interaction/interference of light was studied when two boats illuminated at the close distance. We employed a squid jigging boat (160 kW output for surface lamps) and a lighting boat in a purse-seine fleet (6 kW output for either surface or underwater

lamps), set them at certain positions (200 or 400 m distances) and measured surface and underwater photon flux density between two boats. Interference of light was observed all over the sea surface for a distance of 400 m between boats. It was also confirmed that a distance longer than 350 m might be necessary to avoid an interference of light at the 20 m depth.

Development of a low–drag gear for fuel saving in offshore pair trawl fishery

A low-drag trawlnet partially using Ultra-high-molecular-weight polyethylene (Dyneema) has been tested in the pair trawl fishery in the East China Sea. Fuel consumption, gear shape and its resistance, vessel speed etc. were monitored by using various data loggers. The prototype net reduced fuel consumption to 98% (2% saving) of a conventional net while a net height was 0.5 m increased. We modified the prototype and achieved 4.5% fuel saving without any catch loss. This project continues to achieve better fuel efficiency.

Investigation of fishing technology and its spatial/temporal effort distributions in Lake Victoria, Kenya

Nagasaki University launched a fisheries research laboratory at Kisumu, Kenya, where locate the east end of the Lake Victoria, the biggest lake in Africa. To understand present fishing condition in the lake, we conducted fishing gear design survey at several communities. Lake Victoria produces approx. 95% of fish in Kenya and Top 3 species, Omena (silver cyprinid, *Rastrineobola argentea*), Nile tilapia (*Oreochromis niloticus*) and Nile perch (*Lates niloticus*) account for most of landing in the lake. Omena is harvested by one-boat pelagic seine using lanterns for fish attraction, while Nile tilapia and Nile perch are harvested by gillnets longline and handline fishing. We will investigate spatial and temporal distributions of these fishing activities by using data loggers.

12.11.4   Kagoshima University

[Contact person: EBATA, Keigo < ebata@fish.kagoshima-u.ac.jp>]

Effect of towing condition on survival ratio of shrimps after catch with bottom trawl

Experimental operations of bottom trawl were conducted in Kagoshima Bay to clarify relationship between towing time, and survival ratio of shrimp caught with bottom trawl. After hauling up the trawlnet, shrimps were kept in a tank with aeration for 48 hours. The survival ratio for 48 hours after catch was 70%, 40% and 0%, respectively when towing time was 15 minutes, 1 and 4 hours.

12.12 IRELAND

12.12.1   Bord Iascaigh Mhara

Contact: Daniel McDonald mcdonald@bim.ie.

Codend selectivity in the Celtic Sea whitefish fishery

In 2012, BIM set out to establish the selectivity parameters of two gears put in place to protect juvenile haddock and whiting as specified in EC Regulation 737 of 2012. During October 2013 BIM tested the selectivity parameters of 4 further juvenile haddock and whiting 'friendly' gears in Celtic Sea (ICES VIIf,g and j) whitefish fisheries. The hooped

covered codend method was used attached to a single whitefish trawl and MFV North-ern Celt, a 22m stern trawler, facilitated the trials.

The gears tested were:

- 80mm codend (single 6mm PE) and 140mm SMP (megrim/monk fishery)
- 100mm codend (double 4mm PE) and 160mm SMP (megrim/monk fishery)
- 110mm codend (double 4mm PE) and 100mm SMP (haddock/ whiting fish-ery)
- 120mm codend (double 4mm PE) and 100mm SMP (haddock/ whiting fish-ery)

The data collected in the 2012 and 2013 trials will allow Industry to identify gears that comply with current Regulations and should also allow them to make gear choices that will allow them to operate efficiently and comply with future discard bans/ landing obligations.

Swedish Grid and 110mm SMP trial in Irish Sea Nephrops fishery

Following the introduction of EC 737 of 2012, Nephrops fishers operating in the Celtic Sea are required to place a SMP of up to 110mm mesh size no more than 9m from the codline. These fishers often make regular moves to fish in the Irish Sea where they may also be required to fit a Swedish Grid. Concerns arose that a 110m SMP fitted aft of a Swedish grid might lead to losses of marketable Nephrops. A short trial was conducted on board MFV Mater Dei in August 2013 to address these concerns. No appreciable losses of Nephrops were observed during the trial.

Seal depredation and bycatch in Irish set-net fisheries

In 2013 BIM published the results of a 3-year study to quantify seal depredation of Irish bottom-set gillnet and tanglenet fisheries. The study also recorded the number of seals taken as bycatch in bottom-set-nets. Depredation and bycatch mitigation measures were suggested in the report and further work will assess the effectiveness of these measures.

Waste Management

In 2013, a total 70,000kg of used monofilament nylon netting was collected, packaged and exported to Poland and Lithuania for recycling. Since 2005, approximately 400,000kg of waste nylon has been recycled successfully as a result of this project.

Environmental Management Systems

During 2013, BIM continued to work closely with the fishing industry to further im-plement the Seafood Environmental Management Systems developed over previous years. Part of this work includes the development of the Responsibly Sourced Standard (RSS). In 2013, a total of 80 vessels and 6 onshore facilities had achieved RSS. In order to gain the RSS Fishing vessels must maintain an Environmental Management System to demonstrate responsible practice in fishing such as complying with Technical Con-servation Measures etc.

12.13 ICELAND

12.13.1 Marine Research Institute

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Codend size selectivity for different trawl designs– gadoids

After observing low codend selectivity on a commercial trawler, a selectivity experiment for cod was conducted in September 2013, comparing bottom trawls of different sizes and designs, with two different codends with 135 mm mesh sizes. The codends were of PE materials of different stiffness with twine diameters of 2 x 6 mm (10.4 gm^{-1}) and 2 x 6.2 mm (15.85 gm^{-1}). There were strong interactions between trawl size and codend stiffness. Trawl size affects size selection no less than the codend. The L50's were unexpectedly low or below 37.5 cm in all cases and decreased with increasing trawl size and codend stiffness. It is of concern that those gear combinations are common for the fleet, and the L50's are far below the reference length of 55 cm for cod. Regardless of trawl size, we conclude that the mesh size regulations are not in line with the management aims of avoiding catches of fish below 55 cm. Further studies on different type of codends believed to give more stability in selectivity are planned but not yet on time schedule. (HAE)

Attraction and trapping of cod

Fishing trials with traps using light attraction will start again in May and the plan is to finish the project in autumn. The spinoff project "Grazing cod on krill (Euphausiids) in pens" is finished and final report expected at the end of this year. The other spinoff project "Biology and utilization of krill in Isafjord-deep" is also finished. The biomass of krill in the Isafjord-deep has been estimated and fishing trials carried out with experimental fine-mesh pelagic trawl. Further fishing trails are planned in August-September this year. (EH)

Harvesting of bivalves – new technology

A new project was started in 2012 to find alternatives to dredging when harvesting bivalves, after assessing other current studies and projects with the aim of reducing impact of dredging. As most of the ongoing projects focus on improving dredges and other innovative ideas where scarce, it was decided to focus the project on the mechanisms of picking up scallops from the seabed. With selectivity in mind as the key aim, an experimental vehicle was built using simple and available technology. In 2013, this vehicle was deployed twice. Old scallop grounds in Isafjord-deep where mapped and the pick-up device successfully tested. During the stock-assessment of scallops in Beidafjord the vehicle was deployed and further test were run on the pick-up prototype in areas of high scallop density. After verifying basic principles further refinement of the prototype will follow in 2014. (GH)

12.14 FRANCE

LANGVIVANTE project: Better selectivity and quality for Nephrops

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Ifremer Fishing gear technology and biology laboratory - Lorient

This project represents the first part of a more global project aiming at improving the quality of Nephrops caught in high-sea fishing for the French and the export markets. The LANGVIVANTE project is carried out by the French company "La Houle", financed by "France Filière Pêche"; Ifremer and IDMer are partners of the project. It has begun on March 2013 and should end in October 2014. Ifremer is involved in the selectivity part of the project, the objective of which is to improve in a significant way the selectivity of the Nephrops twin trawls with the aim of an optimization of catches (commercial size) and better quality (liveliness, resistance…).

To reach this goal, a series of hypotheses are tested:

1) The tested selective devices allow reducing the volume of capture while preserving the individuals of commercial interest.

2) The volume reduction of capture in the codend allows increasing the proportion of very alive Nephrops during the sorting with the aim of their possible storage in pools on board.

3) The reduction of trawl duration would have a significant effect on the proportion of very alive Nephrops during the sorting.

4) The use of a codend specially designed to avoid crushing fish and to retain water in the codend during hauling; besides the selective devices would have a significant effect on the proportion of very alive Nephrops during the sorting.

Two experimental trips are planned on a commercial vessel in the Celtic Sea in May and June 2014.

"SELECFISH" project: Fish selectivity in the Channel and North Sea

Weiller Y.[1], Reecht Y.[2], Vermard Y.[2], Coppin F.[2], Delpech J-P.[2], Morandeau F.[3], 2014.

[1] Le Comité Régional des Pêches Maritimes et des Elevages Marins (CRPMEM) Nord-Pas-de-Calais / Picardie, 12 rue de Solférino, 62 200 Boulogne-sur-Mer.

[2]. Le laboratoire Ressources Halieutiques, Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer), 150 quai Gambetta, BP 699, 62321 Boulogne-sur-Mer.

[3]. Le laboratoire Technologies Halieutiques, Institut Français de Recherche pour l'Exploitation de la Mer (Ifremer), 8 rue François Toullec, 56100 Lorient.

The SELECFISH project aimed to test and to develop selective devices for the French artisanal trawlers fleet from eastern Channel and the North Sea. It was funded by the association "France Filière Pêche", by the French State and the Nord-Pas de Calais-Picardie Council. SELECFISH was carried out by the CRPMEM (Regional Fisheries Committee). The pursued goal was to allow a reduction of discards operated by this fishery, and more particularly of the species submitted to the landing obligation established by the new Common Fishery Policy. Effects of tested devices were thus evaluated on whiting, plaice, horse mackerel, herring (species subjected to the landing obligation and strongly rejected by this fishery) and squid, cuttlefish, red mullet, mackerel and cod (commercial species of importance for these fisheries).

The project allowed a test of square mesh cylinders (SMC) of various sizes (80, 100 and 115mm gauge) and various lengths (1 and 2m). The association of SMC (80mm gauge, 2m long) with selective grids was also tested. Each device was tested at sea for at least 5 days on board professional fishing vessels. The method used to carry out the tests is parallel hauls: two trawlers fish side by side, one equipped with the selective device,

the other not, they begin to fish and haul the trawl at the same time and trawl with parallel routes in order to be able to compare the catches of the two devices.

Two observers were embarked on board each ship in order to sample the catches. Tested devices allowed a reduction of discards from 20 to 78% according to the devices. Their use is not without causing immediate commercial losses that vary between 0 and 35% of the sales for a week of trial. SMC have interesting effects on whiting: they allow a large reduction of discarded quantities (from 35 to 60%) while maintaining or even increasing the marketable catches. These SMC are also very effective to let escape small pelagic species (horse mackerel, herring, and mackerel). Their effects on flat fishes are not very interesting (except for the biggest mesh sizes) as they let escape as much (sometime even more) marketable catches than discarded ones.

The 80mm mesh size 2m long SMC, combined with semi-rigid grids in polyurethane, gave varied results but not necessarily much more interesting than the only SMC. With previous semi-rigid grids used in the SELECMER project (23mm bars spacing), the results on whiting are similar than with the SMC alone. On the other hand, we got with this device a better escapement of flat fishes. With SAUPLIMOR rigid grid discards are decreased by almost 80%. Associated commercial losses are nevertheless very important (in particular because of cuttlefish and squid catches divided by two).

These tests highlight once again all the complexity of selectivity improvement for these multispecies fisheries. Tested devices are thus to use in specific cases, for targeted species, but could not be appropriate for an all year-round single selective device.

"REDRESSE" project: selectivity in the Bay of Biscay

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The carrier of the project is the AGLIA (Association du Grand Littoral Atlantique). Other partners are Ifremer, CNPMEM (French National Fishermen Committee) and the South Western Waters RAC (Regional Advisory Council). The financial partners are « France Filière Pêche » association and the four Regions Councils of the Atlantic façade, Brittany, Pays de la Loire, Poitou-Charentes, Aquitaine. The duration of the project is of two years from January 2014 until December 2015.

The objectives are to test strategies and devices allowing reducing discards of the flotillas of the Bay of Biscay. This project will concern the following flotillas:

- Bottom trawlers: Nephrops and fish
- Netters: gillnet and trammelnet
- Pelagic trawlers: small pelagic fish and tuna
- Danish seine: whiting and red mullet

The REDRESSE project is based on a review of the existing knowledge and the strategies that could be implemented as well as on the experiments carried out on commercial boats. REDRESSE will feed on current projects on this theme (CarRejet, carried out by the CNPMEM / SIMBAD, carried out by the Southern RAC for the Spanish and Portuguese flotillas) and any previous and international projects on selectivity improvement.

Ifremer contributes to the data analysis of the programs of observation on commercial vessels (OBSMER) to define the objectives of discards reduction in terms of species and percentage. Ifremer also ensures a technical support (workshops to select devices with the industry at the Lorient flume tank, video observation to optimize the selective devices, assistance to their implementation for the experiments and for the data analysis. All the trials at sea will be carried out on private vessels.

Improvement of selectivity in the Celtic Sea

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The OBSMER program of observation showed that, in trawling multispecific fisheries in the Celtic sea, Western Channel and West Ireland, the discards represent on average 20% of the total captures.

This project concerns the deep-sea trawlers operating in Celtic Sea and in Western Channel. These vessels (approximately 200) based in the ports of Lorient, Concarneau, The Guilvinec, Loctudy, Saint-Guénolé, Saint-Quay Portrieux and Erquy produce annually 35 000 tons for a 100 million euros turnover.

The carrier of the project is fishermen's organization "Les Pêcheurs de Bretagne". Other partners of the project are Ifremer and the equipment manufacturer LE DREZEN. The financial partners are the association « France Filière Pêche » and the Brittany Region Council.

The objectives are identical with those of the REDRESSE project but are limited to the trawling fishery and target more particularly the following species: whiting, haddock, boarfish, gurnards, skates, monkfish…

Devices selected during workshops with the industry are a square meshes cylinder, a T90 extension, as well as a semi-rigid monkfish grid with or without a concentrating

PREDADOR project: Limiting predation of shells by gilthead sea breams

Contacts:

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Yves Le Gall (yves.le.gall@ifremer.fr), Ifremer sismic acoustic unit

Gilthead sea breams cause a mortality of the young shells in diverse zones in particular Brittany the South. The damages concern the oyster and mussels farming. Some parades exist but are not completely satisfactory. The project aims at qualifying better the phenomenon and at experimenting solutions basing on complementary sectors: generator of repulsive / attractive sounds, implementation of physical barriers (net, lines and floats with frighting devices…).

The works will be supervised by the Shellfish Farming Regional Committee of the south Brittany (CRC Bretagne Sud) with as other partners:

- various teams of Ifremer on acoustics, physical systems of protection and observation of the behaviour of fishes, the study of sea breams behaviour in captivity.
- the National Natural History Museum on fish biology.
- the Oyster Syndicate of the Bay of Quiberon and several representative shellfish farming companies of the Bay of Quiberon and Brest harbour.

This project is financed by the Regional council of Brittany, the Department of Morbihan, and by the contribution of the industrial and scientific partners.

Lower impact on the seabed and energy savings

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"Deepsea" EU project: reducing the impacts of deep fishing trawls

Deepsea EU project aims at reducing the impact of deep fishing trawls and reducing there discards. We have developed and tested a trawl with off bottom groundgear (and a light gear option in case of unsuccessful "off bottom gear"). The engineering parameters of this trawl are assessed by the mean of simulation, tank trial and sea trails. The reduction of discards is undertaken by the mean of spatio-temporal and practices strategy. Sea trials were undertaken by the end of 2013. Off bottom gear, behaviour could not be observed. Light gear option was successful with comparable catch rates and strongly reduced pressure on the seabed. Project ended by the end of 2013.

"Jumper": Low impact trawl doors

"Jumper" is an 18 months national project with private funds. It is a continuation of previously developed low impact trawl doors (part of DEGREE EU project and OPTIPECHE French project). The objective is to improve these doors in order to make them applicable to most fisheries where herding effect of doors is not concerned. Numerical simulation of the door behaviour, tank trials and field trials aboard 12m, 25m and 45 m trawlers are undertaken along the project. Trials aboard 25m and 16m trawlers were undertaken in 2013.

"SOS Stabilité": A project to study and improve dynamic stability of small fishing vessels

This three-year project focuses on 12 to 25 m long fishing vessels. The objective was to develop numerical models to analyse the dynamic stability in particular hydrodynamic phenomena such as slamming or phenomena associating possible fishing gear obstruction ... Second objective was to develop electronic systems to assist the skipper in these particular circumstances. Validation was conducted using tank trials and half scale demonstrator used at sea. Training and communication have been addressed to fishers. Partners involved are engineering offices in naval architecture and hydrodynamics. Ifremer brings its skill in fishing gear simulation. SOS-Stabilité has ended mid-2013, after a prolongation of 18 months.

SOIP (French acronym for Service for Optimization and Innovation for Fisheries)

SOIP is a national funded project (Association France Filière Pêche). The carrier of the project is F2DP (Sustainable Fisheries Development Fund). Other partners are Ifremer

and the equipment manufacturer 'Les Docks de Kéroman". The project is funded by the association "France Filière Pêche" and Ifremer.

This project aims at establishing a state-of-the-art regarding the trawl gears used by fishers along the French coasts and how they can be adjusted to their nominal operating point in order to minimize energy consumption and maximize fishing efficiency. About 40 trawlers will be addressed by SOIP. Tension and geometry are measured on the fishing gear and simulations are undertaken by six fishing gear technicians.

Numerical simulation: DynamiT and successor

No further development was achieved on DynamiT software (simulation of trawl gears). The successor of DynamiT is still under development. It will potentially address other types of fishing gears, DynamiT being only dedicated to trawl gears.

ENERSENNE Project:

Contact : Daniel PRIOUR (daniel.priour@ifremer.fr), Laboratory behaviour of the structures at sea

The main objective of the Enersenne project is to estimate the consumption of fuel for the fishing technique of the Danish seine. This project is funded by the association France Filière Pêche. The project is carried out by Ifremer. Other partners are the company Marinelec (electronic at sea), the fishing company Richard in Les Sables d'Olonne, and the Naval School in Brest.

Different types of sensors are implemented to get data to model the various phases of the fishing operation.

The trials at sea with the sensors are in progress on a Danish seiner in the Bay of Biscay.

Once the first recordings were realized, a first study will allow to determine energy consumptions for various phases: sailing, shooting and hauling. The modelling of the hauling phase is finalized.

The energy consumed during hauling can be shared into energy of friction on the bottom and into energy of the hydrodynamic drag of cables and net.

BENTHIS project: Benthic ecosystem fisheries impact study

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Coordinator of Benthis project: Adrian RIJNSDORP (adriaan.rijnsdorp@wur.nl)

website: http://www.benthis.eu

The BENTHIS project began in October 2012. This European project aims at understanding better the effects of fishing on the marine ecosystems to minimize them, while making sure of the economic and social viability of possible alternative measures or of improvement of existing techniques. Its approach an approach aims at the compatibility between the financial necessities of the industry, environmental protection and fisheries policy. This multidisciplinary project is planned to last 4 years. It involves biologists, technologists and fisheries economists, in partnership with professionals of the fishery and will allow studying key issues to direct the fishery to more sustainable practices, based on strong knowledge, collected within the framework of an integrated project fishers-scientists.

The Nephrops fishery in the Bay of Biscay will more particularly be studied as French study case. To do it, two professional fishers practising respectively the Nephrops twin trawling and shellfish traps were requested. For the project, one trawler will use twin trawls and single "double codend" and the second boat will use Nephrops traps.

The project aims to assess: (1) the impact of the practice of trawling (2 designs) and Nephrops traps on the structure of the exploited populations, on the animal and vegetable species of the area and more generally on the ecosystems; (2) the impact of phenomena independent from fishing on the ecosystems (strong tides, storms, season, etc.); (3) the impact of the intensity and the distribution of the various activities of fishing on the ecosystem (4) the evolution of the yields of Nephrops traps in an area exclusively and significantly fished with this gear; (5) the rates of secondary captures depending on gear, seasons… (6) the economic viability of these fishing techniques, or potential improvements of techniques or modalities of spatial management of the activity.

The first period of Benthis Project (18 months) ended in April 2014. In order to better identify processes linked to benthic impact of trawling gears on Nephrops benthic communities and habitats of the Bay of Biscay, we organized in 2013 two surveys (FEBBE 1 and 2). Those surveys were designed to identify modifications induced by trawling activities on both sediments structure and composition and all the bentho-demersal compartments (from meio to megafauna). The sampling strategy was defined according to existing trawling gradients.

During that project period, we clarified the definition of selected alternative gears and strategies. For the case study relative to Nephrops fishery we will mainly test for effect of alternative trawling gears modifications:

- Replacing classical otter boards of twin trawls by less impacting boards (i.e. "jumper doors") having much lower contact with the bottom.
- Completing already made tests in previous studies about validity of traps utilization in Nephrops fishery.

Analysis will be especially based on data acquired from dedicated field survey in order to evaluate direct impact (on habitat and benthic) of new vs. classical gears. Moreover, application of an auto-observation protocol applied all the yearlong onboard vessels of fishers partners will give us information about technical issues, efficiency and economic viability of new gear. We will test for alternative spatial management strategies too by deeply analysing spatial dependency between fishery, dynamic of exploited populations and benthic habitat. That work will be achieved through a spatially explicit modelling framework (ISIS-Fish) allowing us to test for different scenarios.

Alternative fishing gears

FREGATE project: Better selectivity and quality for Nephrops

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Ifremer Fishing gear technology and biology laboratory – Lorient

In parallel with its work on "motorization", the Fish2EcoEnergy program launched the development of alternative or complementary fishing techniques to trawling, in particular the study concerning pots fishing in the North Sea and Channel. The Ifremer Fishing gear technology and biology laboratory in Lorient, which has already introduced several works on this emergent technique in France, works with the association

"France Pêche Durable et Responsable" to test and implement fish pots on board the private trawler "Frégate".

These trials that have begun in the early 2014, will allow estimating, in professional conditions of use, the environmental and economic potential of this fishing technique, still little known on our coasts.

Contribution to stock assessment

"BARGIP" project: Assessment and management of the Sea bass fishery

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Fabien MORANDEAU (fabien.morandeaut@ifremer.fr), Ifremer Fishing gear technology and biology laboratory – Lorient

This integrated project aims to improve the assessment and management of the Sea bass fishery. The fishing gear technology unit was appealed to implement a small trawlnet for sampling Sea bass juveniles (5 to 30 cm) in estuaries or rivers.

Adaptations were necessary to implement the trawlnet, initially planned for the capture of fish sizing a few centimetres. The trawl was simulated thanks to the Ifremer DYNAMIT software. The choice of the trawlnet went towards a four faces trawl used on small longliners practising trawling to catch baits. Adaptations are possible to make the trawlnet more filtering and being able to work on relatively high speed. Globally the concept was validated to become one of the technical ways allowing the success of the project.

13   Other Business

13.1 Date and Venue for 2015 WGFTFB Meeting

The **ICES-FAO Working Group on Fishing Technology and Fish Behaviour** will meet in Lisbon, Portugal from 4–8 May, 2015, at the invitation of Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal.

13.2 Topic Groups for 2015 WGFTFB Meeting

The topic group on 'Technological Innovation in Spreading Trawls' will meet at the WGFTFB in 2015. Three new topic groups have been proposed for the 2015 WGFTFB meeting: non-extractive fisheries sampling; change management in fisheries; and contact probability of selective devices; and will meet at the WGFTFB in 2015.

The topic groups on 'Artificial light in fishing gear' and 'Dynamic Catch Controls' will work by correspondence and present their final reports for at the 2015 WGFTFB meeting.

13.2.1 Ongoing Topic Group: Technological Innovation in Spreading Trawls

A WGFTFB topic group of experts, convened by Paul Winger (Canada), Bob van Marlen (Netherlands), Antonello Sala (Italy), will be formed in 2014 to document and evaluate recent technological advancements in spreading technology for mobile trawls. The terms of reference will include:

i)   Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.

ii)   Review technical challenges and obstacles for uptake by industry.

iii)   Identify new applications for these technologies and opportunities for technology transfer.

Justification:

Mobile bottom trawls are known to produce ecological impacts in many fisheries (He and Winger, 2010; Lucchetti and Sala, 2012). The devices used to spread these trawls (typically doors) contribute heavily to fuel consumption and seabed impacts. In response to these concerns, several countries have initiated research projects in recent years toward the development of creative and innovative approaches to spreading mobile trawls. Moving beyond basic doors and beams, new research efforts are now breaking ground toward off-bottom doors, manoeuvrable or steerable doors, kites, and hydrodynamic beam concepts. A synthesis of these technological advancements will provide up-to-date information, stimulating innovation and opportunities for technology transfer.

References

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Lucchetti, A., Sala, A. 2012. Impact and performance of Mediterranean fishing gear by sidescan sonar technology. Canadian journal of fisheries and aquatic sciences, 69: 1806–1816.

13.2.2 Proposed Topic Group: Non-extractive fisheries sampling

A WGFTFB topic group of experts, convened by Shale Rosen, Institute of Marine Research, Norway (shale.rosen@imr.no) and Haraldur Einarsson, Marine Research Institute, Iceland (haraldur@hafro.is) will be formed in 2015 to evaluate current methods and recent technological advances applicable to sampling without physically removing organisms from the sea. The topic group will have the following terms of reference:

i)   Summarize current needs for non-extractive sampling (e.g.. regulatory restrictions, sampling threatened or endangered species, sampling in sensitive or protected habitats)

ii)   Inventory currently available equipment and techniques

iii) Identify current gaps between available technology and sampling needs

Justification:

Fisheries are one of the few disciplines in biology where data collection continues to rely on the removal and destruction of the organisms being studied. This practice has come under increasing scrutiny in recent years. Research projects have been terminated due to denied permits; researchers have had difficulty publishing results due to animal welfare concerns and in some instances, research budgets have had to absorb the cost of purchasing quota for the fish captured. Research focused on fishing gear design and selectivity, a major focus of the members of the Working Group on Fishing Technology and Fish Behaviour, is particularly vulnerable to such restrictions due to the need to conduct tests with commercial-scale catches.

Fisheries Acoustics is a mature solution, but is addressed by the Working Group on Fisheries Acoustics Science and Technology and will therefore not be taken up by this topic group. Techniques for collecting and analysing underwater images have advanced significantly in recent years, and may fill many sampling needs. In habitats that are difficult to sample or for fragile species, no-catch techniques may also provide better information than traditional methods that rely on catching the organisms of interest and bringing them to the surface. New observation techniques to quantify all fish entering a fishing gear could revolutionize selectivity studies by eliminating the need for control sampling gear, codend covers, or trouser trawl configurations (released fish could be calculated as the difference between the numbers of individuals entering the gear minus the fraction retained after the selectivity device).

A thorough review of the problems, existing solutions, and technological gaps will assist FTFB members in both their own research and in the role they often play advising other fishery biologists in designing and carrying out surveys.

It is proposed that the topic group runs for two years. Year 1 will focus on a review of both peer-reviewed and grey literature on current needs for non-extractive sampling and techniques/systems that are currently available or under development. Year 2 will focus on synthesizing the results into a review paper with recommendations for how to implement non-extractive sampling techniques as a part of standard fisheries research.

13.2.3 Proposed Topic Group: Change Management in Fisheries

A WGFTFB topic group convened by Steve Eayrs and Michael Pol aims to evaluate the application of change management concepts and models in a fisheries context and recommend new approaches to facilitate change in the fishing industry. The terms of reference are:

i) Evaluate the applicability of change management concepts and models in a fisheries context

ii) Review and evaluate fisheries case studies and initiatives to bring about change, including Knowledge networks, Environmental Management Systems, Fisheries Improvement Projects, and others

iii) Explore models of human behaviour that may contribute to resistance to change

iv) Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

Justification:

Despite a plethora of efforts by fishing technologist, conservation engineers, and others to reduce the environmental impacts of fishing and increase fishing efficiency and profitability, commercial fishers are generally highly resistant to changing their fishing gear and practice. In the business world, responses to change are increasingly being guided by change management concepts and models; however, their application to the fishing industry has been scant, piecemeal, and incomplete. These concepts and models provide greater understanding of resistance to change and could potentially provide an insight into new approaches to facilitate change in the fishing industry. By reviewing knowledge of these concepts and models, and past efforts to facilitate change in fisheries including holistic approaches such as Knowledge Networks, Environmental Management Systems, and Fishery Improvement Projects, we hope to identify circumstances, models, techniques, and approaches that will result in smoother, more cost-effective change initiatives in the fishing industry in future.

References:

Cameron, E., and M. Green. 2012. Making sense of change management. A complete guide to the models, tools and techniques of organizational change. 3rd edn. Replika Press, India. 491 pp.

Eayrs, S., Cadrin, S., and Glass, C. *In press*. Managing change in fisheries: a missing key to fishery dependent data collection? ICES Journal of Marine Science.

Glass, C. W., Eayrs, S., and Cournane, K. M. *In press.* Bycatch reduction devices: Development, adoption, and implementation? Fisheries Bycatch: Global Issues and Creative Solutions. Alaska Sea Grant.

Kotter, J. P. 2008. A sense of urgency. Harvard Business Press. 196 pp.

13.2.4 Proposed Topic Group: Contact Probability of Selective Devices

A WGFTFB topic group of experts convened by Daniel Stepputtis and Bent Herrmann will be formed in 2015 to investigate, understand and improve the contact probability of specific selective devices (e.g. grids, netting). It will **document and evaluate** current and past work regarding the influence and improvement of contact probability. This will include studies from a wide range of scientific fields, such as selectivity, behaviour, hydrodynamics and gear design. Special attention will be given to investigating how to improve the performance of gears and selective devices with suboptimal selective properties.

The terms of reference are:

i) Summarize current and past work in relation to contact probability

ii) Discuss and describe methods (experimental and statistical) to investigate and quantify contact probability

iii) Investigate and make recommendations on how to improve contact probability in selective devices, including

   a) Identification of gears and selective devices with suboptimal contact probability (preferably based on current gear trials from group members)

   b) Discussion on potential causes and solutions

   c) Recommendations on experimental/theoretical work to understand and improve the contact probability

Justification:

Over the past decades, numerous selective devices have been developed and tested. Many of them did not fulfil expectations and even those that are now being used can probably be improved.

A key factor influencing the effectiveness of selectivity devices is the probability of a given specimen to contact the specific selection device. Nevertheless, this factor is often not sufficiently considered when developing selective devices. Additionally, few selectivity studies have quantified the contact probability of these devices although it underpins how they perform and how they can be improved.

This Topic Group will be highly relevant to the further development of sustainable fisheries, especially in the light of discard ban, single and multispecies selectivity and potentially also for balanced harvesting - in a wider sense.

13.3 Reports from associated expert groups

13.3.1 Report from WKMEDS

Mike Breen made a presentation on the work carried out by the ICES Workshop on Methods for Estimating Discard Survival (*WKMEDS*)

The latest report of WKMEDS is available online: *www.ices.dk/sites/pub/.../WKMEDS/WKMEDS%20Report%202014.pdf.*

13.3.2 Report from SGELECTRA

The Study Group on Electrical Trawling (SGELECTRA), chaired by Bob van Marlen, the Netherlands and Bart Verschueren, Belgium, met in Ostend, Belgium, 22–24 October 2013. A total of 10 participants attended from Netherlands, Belgium, Germany, Scotland, and France. The meeting began with a short review on the history of research of pulse trawling (on flatfish), and the ICES Advice on Pulse Trawling on flatfish of 2006 and 2009, and the following tank experiments carried out by IMARES. Further data analyses by IMARES, IJmuiden, The Netherlands, were presented and discussed, on the catch comparison of May 2011 on the two pulse trawl vessels TX36 and TX68 and the conventional tickler chain beam trawl vessel GO4, and new reference measurements of field strength in situ in 2013 on the TH7. An updated presentation was also given about the development of the pulse trawl for the brown shrimp (*Crangon crangon* L.) fishery by ILVO, Ostend in Belgium, and work to be carried out by two PhD students from the University of Ghent in cooperation with ILVO. This work has been given follow-up in The Netherlands on three commercial vessels, and a project

on shrimp fishery using the Marelec-Crangon-pulse-beam trawl in Germany on a commercial boat has recently finished the practical phase. In addition, an update was given on the razor clam (Ensis) fishery in Scotland in which electrical stimulation is used. The documents produced by the Netherlands Control and Enforcement Group and draft Procedure for Control and Enforcement were presented and discussed. The reviewing experts concluded that: SGELECTRA recommended continuing work in 2014–2016 with new name WGELECTRA and new Terms of Reference.

13.4 Proposals for 2015 ASC Theme Sessions

Even though some of the ideas were discussed, but no concrete proposals for the ASC theme session were put forward.

Annex 1: List of participants

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Annex 2: Agenda

Sunday May 4	
Fairfield Inn	
16:00	Registration
18:00	Registration ends

Monday May 5	
New Bedford Whaling Museum	
8:00	Registration
8:30	Opening/Welcome
	John Mitchell, Mayor of New Bedford
	Paul Diodati, Director of Massachusetts Division of Marine Fisheries
	Bill Karp, Director of NOAA Northeast Fisheries Science Center
	Mohammad Karim, Provost and Executive Vice Chancellor of University of Massachusetts Dartmouth
9:15	JFATB Scientific talks
9:55	Break
10:15	JFATB Scientific talks
11:55	Lunch break
13:25	JFATB Scientific talks
14:45	Break
15:05	JFATB Scientific talks
16:20	ICES Strategic Plan presentation (Fred Serchuk, USA delegate to ICES)
16:40	ICES Science Plan presentation (Nils Olav Handegard, Chair of ICES SSGESST)
17:00	End
Evening	Reception (Whaling Museum)

Tuesday May 6	
8:00	Registration
9:00	Opening/Welcome
9:20	**Bob Van Marlen** and Kees Goudswaard
	Survival experiments in the Netherlands in 2012 and 2013
9:20	**Carwyn Hammond,** Craig S. Rose and John R. Gauvin
	Can we reduce unobserved crab mortality from bottom trawling in the Bering Sea? Accomplishments with cooperative research and trawl gear modifications.
10:00	**Eduardo Grimaldo,** Manu Sistiaga, Bent Herrmann and Roger Larsen
	The effect of lifting panel on grid-based selectivity
10:40	Break
11:10	**Julio Garcia** and Ricardo Roth
	Hake selectivity trials with Argentine trawl fishing industry
11:30	**Mochammad Riyanto** and Takafumi Arimoto
	Temperature effect on heart rate and white muscle activity during swimming exercise of jack mackerel, Trachurus japonicas
11:50	Barry O'Neill and Keith Summerbell
	Recent Scottish trials on the physical impact of trawl gears
12:10	Ron Smolowitz, Farrell Davis, Christopher Parkins
	The evolution of New Bedford style scallop dredge
12:30	Lunch
14:00	**Craig Rose** and Carwyn F. Hammond
	Addition of light to an experimental footrope caused increased escapement of one flatfish species
14:20	**Emilio Notti** and Antonello Sala
	Effects of a new magnetic device on the fuel consumption of fishing vessels
14:40	**Truong Nguyen**, Paul Winger, Dave Orr, George Legge, Harold Delouche, and Alex Gardner
	Computer simulation and flume tank testing of scale engineering models: How well do these techniques predict full-scale at-sea performance of bottom trawls?
15:00	**Nina Madsen,** Karl Gunnar Aarsæther, and Bent Herrmann
	Simulating the physical behaviour of seine ropes for evaluating fish herding properties of Danish seines
15:20	**Melanie Underwood**, Arill Engås, Shale Rosen, Asbjørn Aasen
	Excess Fish Exclusion Device (ExFED): How to passively release fish at depth during trawling
15:40	Ólafur Arnar Ingólfsson, Bjørn Totland, Jostein Saltskår, Shale Rosen
	Catch limitation in demersal seines
16:00	Break
16:20	**Michael Pol**, Steve Eayrs, Pingguo He, Erik Chapman, Jon Knight, and Mike Walsh
	GEARNET: Summary and successes of a new approach to conservation engineering
16:40	**Steve Eayrs,** Chris Glass, and Steven Cadrin
	A framework for change in commercial fisheries: Can a new approach provide additional benefit to fishers and others?
17:00	General discussion
17:30	End

Wednesday May 7	
8:45	Opening/Welcome
8:50	Introduction: FTFB Special session on "Selective fishing and balanced fishing" (chair)
9:00	**Petri Suuronen,** Pingguo He, Mike Pol, Norman Graham and David Reid
	Selective, non-selective and balanced fishing
9:20	**Takafumi Arimoto**, U.Khrueniam, T.Yoshikawa, K.Kon, Y.Okamoto, S.Ishikawa, *et al.*
	Mean trophic level analysis as indicator for balanced harvesting - Cast study on Japanese-type set-net, in Thailand
9:40	Paraskevas Vasilakopoulos, **Barry O'Neill,** and Tara Marshall
	The unfulfilled potential of fisheries selectivity to promote sustainability
10:00	**Daniel Stepputtis,** Juan Santos, Bent Herrmann, and Bernd Mieske
	Alternative strategy for size selectivity of trawls
10:20	Break
10:40	**Adnan Tokaç,** Bent Herrmann, Gökhan Gökçe, Ludvig Krag , Arcan Ünlüler, Davod Nezhad, *et al.*
	Understanding and predicting the size selectivity of red mullet (Mullus barbatus) in Mediterranean bottom trawl codends with different mesh configurations
11:00	**Bent Herrmann,** Roger Larsen, Bjørnar Isaksen, Manu Sistiaga, Nina Madsen, and Karl G. Aarsæther
	Understanding and predicting size selection of cod (Gadus morhua) in square-mesh codends for Danish Seining: a simulation-based approach
11:20	**Michael Pol**, Bent Herrmann, and Pingguo He
	Trouser trawl selectivity trials to help re-establish an Acadian redfish Sebastes fasciatus fishery in the Gulf of Maine
11:40	Discussion
12:00	Site visit - Woods Hole and vicinity/Cape Cod Canal (Bus leaves from Fairfield Inn, details to follow)
17:00	Return to New Bedford
Evening	Site visit - Reidars Trawl Gear& Marine Supply (Details to follow)

Thursday May 8	
8:45	Announcement/Logistics
9:00	Topic group meeting
	TOR a - Catch control (Room "Cuttyhunk", chaired by Grimaldo, Pol and He)
	TOR b - Light (Room "East Chop", chaired by An, Palm and Zhou)
	TOR c - Vessel/gear (Room "Seaview", chaired by Sala)
	TOR d - Trawl spreading (Room "West Chop", chaired by Winger, van Marlen and Sala)
10:40	Break
11:00	Topic group meeting (continued)
12:40	Lunch
14:00	Topic group meeting (continued)
15:40	Break
16:00	Topic group meeting (continued)
17:20	End
Evening	Banquet (Bus leaves from Fairfield Inn, details to follow)

Friday May 9	
8:45	Announcement/Logistics
9:00	**Daisaku Masuda,** Masahiro Maeda2, Shuya Kai, Yoshiharu Sasamoto, Yoichi Yanagino, Kei-ichi Furukawa and Yoshiki Matsushita
	Application of the low-power underwater light to a large-scale trapnet fisher. 2. Sonar observation and tagging experiment
9:20	**Steve Eayrs**
	Semi pelagic doors in the New England Groundfish Fishery
9:40	**Mike Breen,** Eduardo Grimaldo, Kurt Hanssen, Bjørnar Isaksen, Rolf Korneliussen, Gavin Macaulay, Rachael Morgan, Egil Ona, Audun O. Pedersen, Geir Pedersen, Hector Pena, Jostein Saltskår, Benny Svardal, Maria Tenningen, Peter J. Thomas, Bjørn Totland, Jan Tore Øvredal, Aud Vold
	Research into catch control in purse-seine fisheries in Norway
10:00	**Eduardo Grimaldo,** Manu Sistiaga, Jørgen Vollstad, Roger B. Larsen
	Cod and haddock escape behaviour in relation to catch control devices in seine nets
10:20	**Hans Nilsson** and Joakim Hjelm
	Socio-economic Impact of gear selectivity, technical measures and population structure in the Baltic cod trawl fishery
10:40	**Liming Song,** Weiyun Xu and Jie Li
	The dynamic simulation of the pelagic longline deployment
11:00	Break
11:20	Country report summary (Barry O'Neill)
	Report/summary: TOR a - Catch control (TOR convener)
	Report/summary: TOR b - Light (TOR convener)
	Report/summary: TOR c - Vessel/gear (TOR convener)
	Report/summary: TOR d - Trawl spreading (TOR convener)
	WKMEDS report (Mike Breen)
	SGELECTRA report (Bob van Marlen)
12:30	Lunch
13:30	Update on Stationary gear manual (Mike Pol)
	Update on SELDAT (Mike Pol)
	Next meeting - place and time
	New TORs
	2015 ICES ASC proposal
	ICES Symposium proposal
	Announcements and other business
16:00	Adjourn
Topic Groups:	
a	Topic Group on Dynamic Catch Controls (TORA - Catch Control)
	Conveners: Eduardo Grimaldo (Norway), Mike Pol (USA) and Pingguo He (USA)
b	Topic Group on Use of Artificial Lights in Fisheries (TOR B - Light)
	Conveners: Heui-chun An (Korea), Anne Christine Utne Palm (Norway), and Yinqi Zhou (China)
c	Topic Group on Relationships among Vessel Characteristics and Gear Specifications (TOR C – Vessel/gear)
	Convener: Antonello Sala (Italy)

d   Technological innovation in spreading trawls (New; TOR D – Trawl Spreading)

Conveners: Paul Winger (Canada), Bob van Marlen (Netherlands) and Antonello Sala (Italy)

Annex 3: WGFTFB multi-annual terms of reference

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Present recent investigations into and synthesize current knowledge of topics related to: "Design, planning, and testing of fishing gears used in abundance estimation"; "Selective fishing gears for bycatch and discard reductions"; "Environmentally benign fishing gears and methods" and summary of research activities by nation	Through open sessions and focused, multiyear topic groups, the Working Group provides opportunities for collaboratively developing research proposals, producing reports and manuscripts, and creating techncial manuals on current developments and innovations.	21, 34, primarily; others are possible (e.g. 11,133, 223, 33, *et al.*)	3 Years	ICES report;
b	Organize an FAO hosted FAO-ICES mini-symposium with thematic issues as described in the Barange-Matthiesen exchange of letters	Under mutual agreement between ICES and FAO, FAO develops and leads a mini-symposium of relevant topics, while also continuing ICES commitments	21, 34	Year 3	FAO report, ICES report
c	Present recent investigations into topics of mutual interest between WGFTFB and WGFAST	Every third year, WGFAST and WGFTFB meet for one day to share information on topics of mutual interest (JFATB)	16, 21	Year 1	JFATB report
d	Every second year, describe changes in EU fishing fleets and effort relevant to assessment working groups	WGFTFB has produced this advice for several years and been encouraged to continue by Assessment WGs		Years 1, 3	Reports to individual EGs
e.	Organize an ICES-sponsored international fishing technology Symposium	Organize the Third ICES Symposium of Fish Behaviour		Fall 2017 (outside scope of this Multiannual TOR)	Symposium and special issue in ICES Journal of Marine Science

e	Develop survey and gear expertise support for survey working groups via ASC and survey group meetings	SSGESST has identified gear expertise gaps in survey working groups.		Year 1,2	Identify WGFTFB members who can fulfill advisory roles ; Review survey protocols.

Summary of the Work Plan

Year 1	Produce the annual report; hold joint session with WGFAST; inform assessment EGs on fleet effort changes; connect to survey WGs
Year 2	Produce annual report; Continue development of relationships with survey EGs
Year 3	Produce the annual report; inform assessment EGs on fleet effort changes; organize FAO mini-symposium

Supporting information

Priority	The activities of WGFTFB will provide ICES with knwledge and expertise on issues related to the ecosystem effects of fisheries, especially the evaluation and reduction of the impact of fishing on marine resources and ecosystems and the sustainable use of ecosystems and other topics related to the performance of fishing gears and survey gears.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants	The Group is normally attended by some 40–45 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	Linkages to advisory groups via reports on changes to fleets and fleet effort
Linkages to other committees or groups	There is a very close working relationship with all the groups of SSGESST, WGFAST, and the survey groups.
Linkages to other organizations	The WG is jointly sponsored with the FAO.