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Industry-led fishing gear selectivity improvements. How can we increase flexibility and ownership over the gears used whole ensuring an effective introduction of the new EU Common Fisheries Policy?

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Publication date:
2016

Document Version
Publisher's PDF, also known as Version of record

ICES WGFTFB REPORT 2016

SCICOM/ACOM STEERING GROUP ON INTEGRATED ECOSYSTEM OBSERVATION AND MONITORING

ICES CM 2016/SSGIEOM:22

REF. ACOM AND SCICOM

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

25–29 April 2016

Merida, Mexico

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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Recommended format for purposes of citation:

ICES. 2016. Report of the Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 25-29 April 2016, Merida, Mexico. ICES CM 2016/SSGIEOM:22. 183 pp.

Contents

Executive Summary

The ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB) met in Merida, Mexico from 25 to 29 April 2016 to hold a FAO-hosted mini-symposium on "Technology Development and Sustainable Fisheries", and to address four Terms of Reference. The main outcomes related to the mini-symposium and the ToRs are detailed below.

Mini-symposium on Technology Development and Sustainable Fisheries

The two-and-half-day mini-symposium hosted by FAO in collaboration with Marista University of Merida and sponsored by FAO included 40 oral presentations and 14 poster presentations, and was attended by 85 scientists from 23 countries across four continents (Europe, North America, South America, and Asia). The mini-symposium contained six theme sessions:

1) Challenges and advantages in static fishing gears;
2) Encouraging technological change in capture;
3) Energy and greenhouse gas (GHG) reduction in capture fisheries;
4) Technology and practice for managing bycatch and reducing;
5) Innovative technologies for observing fish and fishing gear;
6) Fishing technology to eliminate vaquita bycatch from fisheries in the Upper Gulf of California (UGC) - A Special session in collaboration with World Wildlife Fund (WWF) and US Marine Mammal Commission (MMC).

This mini-symposium represents an opportunity for WGFTFB to meet its goals of providing a forum for global synthesis of scientific knowledge of fishing technology, fish behaviour, and their application in conservation and sustainable utilization of world's marine resources. The symposium drew upon the unique regional expertise in South and Latin America, and advanced our knowledge of the subject matter.

Technical Innovation in Spreading Trawls

The purpose of this Topic Group was to provide a synthesis of recent technological advancements in the spreading of mobile trawls. Contributions were collected over a three-year period (2014–2016) from 29 participants representing 17 countries. Moving beyond basic doors and beams, the Topic Group revealed 17 new and leading innovations in the topic, although in many cases scientific literature is still absent on their engineering and catching performance. They include:

1) Manoeuvrable trawl doors - Norway
2) Controllable trawl doors - Iceland
3) Xstream trawl doors - Denmark
4) Flipper trawl doors - Denmark
5) Ekkó trawl doors - Iceland
6) Batwing trawl doors - Australia
7) Jumper door – the Netherlands
8) Semi-pelagic trawl doors
9) Sumwing and pulsewing – the Netherlands
10) Hydrorig i and ii – USA and the Netherlands

11) Demersal seine rope dynamics

12) Knot orientation

13) Kites/depressors

14) Self-spreading plate gear – Denmark and Norway

15) Self-spreading semi-circle plate gear – Norway

16) Wing trawling system – USA

17) Use of high strength netting material

The findings represent a snapshot in time; it is a picture of innovative technology under development. Looking forward, we are encouraged by the rate of R&D in this field. We see examples of academia, government, and industry all working on innovative concepts. The development and commercialization of novel products by door manufacturers is a particularly encouraging sign.

Non-Extractive Sampling

The topic group on Non-Extractive Sampling was to summarize current needs for non-extractive sampling (e.g. regulatory restrictions, sampling threatened or endangered species, sampling in sensitive or protected habitats), inventory currently available equipment and techniques, and to identify current gaps between available technology and sampling needs. The major findings of the group are as follows:

1) Examples of a switch from fishing gear to non-extractive optical survey technique exist, but in general, the fisheries research community currently has little focus on sampling mortality or how to reduce it during routine investigations.

2) Techniques for modelling mesh selectivity are well developed and can facilitate designing fishing gears with reduced need for at-sea trials and catch of fish.

3) The bottleneck in more widespread use of optical techniques for fisheries investigations is not the imaging technologies, but the facilities for effective storage, catalogue, and analysis of image data.

4) Automated image processing for marine fisheries data are still in the development stage. It is recommended that FTFB members make effort to develop tools for image and video analysis and cataloguing and made available to the wider user communities.

Application of Change Management in the Fishing Industry

The purpose of this Topic Group was to retrospectively evaluate case studies related to change in the fishing industry against the Kotter model of change management, explore models of human behaviour that may contribute to resistance to change, and identify and categorize circumstances and approaches that led to the successful and unsuccessful introduction of change in fisheries. Seven case studies were presented, although not all were evaluated against the Kotter model. The group also explored two additional case studies, which were also evaluated against the Kotter model. The main outcomes of the topic group are as follows:

1) Retrospective case studies identified some or all of the steps of the Kotter model, but no particular step was considered to determine success or failure.

2) Elements of successful change programs were suggested: size of the stakeholder group, stature of participants, clarity of purpose or vision, closures or lawsuits forcing mandatory change, and health of fishery resource or profitability of the fishery.

3) Vessel ownership (non-operator/corporate v. owner/operator) influences appetite and attitude toward change.

4) Readiness to change is an important element in understanding how change occurs, and can be a useful addition to the Kotter model, which focuses on inertia and process.

5) Simplification of regulations might engage fishers in useful innovation instead of harmful innovation.

6) Application of the Kotter model to two case studies highlighted the importance of a careful definition of the vision of a change initiative.

7) Contributions from social scientists with experience in human behaviour and the commercial fishing industry are needed in order to validate and support our understanding of human decision-making.

8) ICES Strategic Initiative on the Human Dimension (SIHD) should be informed of topic group findings and explore opportunities for collaboration.

9) Preparation of an extensive retrospective review for publication that attempts to categorize circumstances and events that contribute to successful and unsuccessful change initiatives in fisheries should be considered.

Contact probability of selective devices

The main purpose of this topic group was to summarize current and past work in relation to contact probability, and methods to investigate and quantify contact probability, to improve contact probability in selective devices to achieve desired outcome of the devices. During the two meetings (2015 in Lisbon and 2016 in Merida), the topic group discussed and elaborated:

1) Definition of "contact" and "contact probability" in the context of selectivity devices,

2) Means and methods to investigate and estimate contact probability of selectivity devices,

3) Importance of contact between fish and the hear for the functioning of successful selectivity devices, and

4) Reasons that a developed selectivity device/concept did not work as desired with regard to contact.

The group concluded that a more detailed investigation and discussion of contact probability between fish and selection device is essential to further improvement of existing and the development of new selective devices. This was also reflected in the numerous contributions to this topic group. However, aside from the general investigation on the contact probability for a given selective device, information on the contribution of different factors influencing the contact probability is often missing.

1 Administrative details

Working Group name

ICES-FAO Working Group on Fish Technology and Fish Behaviour (WGFTFB)

Year of Appointment within the current three-year cycle

3

Reporting year concluding the current three-year cycle

3

Chair(s)

Pingguo He (ICES Chair), USA

Petri Suuronen (FAO Chair)

Rapporteur: Barry O'Neill, UK

Meeting venue(s) and dates

1) 5-9 May 2014 at the FTFB meeting in New Bedford, MA, USA (67 participants)
2) 4-7 May 2015 at the FTFB meeting in Lisbon, Portugal (45 participants)
3) 25-29 April 2016 at the FTFB meeting in Merida, Mexico (85 participants)

2 Introduction

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 environmentally benign 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.

3 Terms of Reference

The **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** [WGFTFB] (Chairs: Pingguo He, USA; Petri Suuronen, FAO) met from the 25 to 29 April 2016 in Merida, Mexico to work on the following specific Terms of References that were developed from WGFTFB's multi-annual ToRs.

Terms of Reference (ToRs):

a) **A mini-symposium on Technology Development and Sustainable Fisheries.** Under a supporting agreement developed in an exchange of letters between FAO and ICES, formalized in 2011, FAO would host the meeting of the Working Group every third year and would be organized as a mini-symposium. FAO, with agreement of WGFTFB members identified the following theme as mutually importance and interests, and with the consideration of the pressing issues of the host country (Mexico):

- Challenges and advantages in static fishing gears
- Encouraging technological change in capture
- Energy and greenhouse gas (GHG) reduction in capture fisheries
- Technology and practice for managing bycatch and reducing
- Innovative technologies for observing fish and fishing gear
- Fishing technology to eliminate vaquita bycatch from fisheries in the Upper Gulf of California (UGC)

Co-chairs: Pingguo He (USA), Petri Suuronen (FAO), and Juan Carlos Seijo (Mexico)

b) **Technical Innovation in Spreading Trawls.** A WGFTFB topic group of experts will meet to document and evaluate recent technological advancements in spreading technology for mobile trawls. The group will have the following terms of reference:

- Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.
- Review technical challenges and obstacles for uptake by industry.
- Identify new applications for these technologies and opportunities for technology transfer.

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

c) Non-extractive fisheries sampling. A WGFTFB topic group of experts will meet 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:

- Summarize current needs for non-extractive sampling (e.g. regulatory restrictions, sampling threatened or endangered species, sampling in sensitive or protected habitats)
- Inventory currently available equipment and techniques

- Identify current gaps between available technology and sampling needs

Conveners: Shale Rosen (Norway), Haraldur Einarsson (Iceland)

d) **Change Management in Fisheries.** A WGFTFB topic group will meet 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:
    - Evaluate the applicability of change management concepts and models in a fisheries context;
    - Review and evaluate fisheries case studies and initiatives to bring about change, including Knowledge networks, Environmental Management Systems, Fisheries Improvement Projects, and others;
    - Explore models of human behaviour that may contribute to resistance to change;
    - Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

Conveners: Steve Eayrs (USA) and Michael Pol (USA)

e) **Contact Probability of Selective Devices.** A WGFTFB topic group will meet 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 will include:
    - Summarize current and past work in relation to contact probability;
    - Discuss and describe methods (experimental and statistical) to investigate and quantify contact probability;
    - Investigate and make recommendations on how to improve contact probability in selective devices, including:
        - Identification of gears and selective devices with suboptimal contact probability (preferably based on current gear trials from group members);
        - Discussion on potential causes and solutions;
        - Recommendations on experimental/theoretical work to understand and improve the contact probability.

Conveners: Daniel Stepputtis (Germany) and Bent Herrmann (Denmark)

4 Participants and Meeting Agenda

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

5 Explanatory Note on Meeting and Report Structure

The partnership of ICES and FAO in jointly sponsoring the Working Group began in the early 2000s. The 2016 meeting was hosted under a supporting agreement developed in an exchange of letters between FAO and ICES, formalized in 2011, in which it was agreed that FAO would host the meeting of the Working Group every third year in a location of FAO's designation, and the meeting would be organized as a mini-symposium. The 2016 meeting was the second held under this arrangement (The first one was in Bangkok, Thailand in 2013). The meeting was hosted by FAO in collaboration with Marista University of Merida, Mexico.

The first three days of the meeting were dedicated to a mini-symposium on "Technology Development and Sustainable Fisheries", with six theme sessions in a symposium format. The fourth and fifth days included meetings of topic groups and WGFTFB business including a review of country reports, as has been the practice of the WG since 2005.

Individual conveners were appointed for topic groups and the mini-symposium during prior meetings or intersession to oversee and facilitate work by correspondence throughout the year and at the meeting. The Chairs asked the conveners to prepare a working document, reviewing their progress on their ToRs and recommendations and conclusions based on the topic group's work. The summaries and recommendations for the working documents for each ToR were reviewed by WGFTFB and were accepted, rejected or modified accordingly to reflect the views of the WGFTFB. However, the contents of these working documents do not necessarily reflect the opinion of the WGFTFB. 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, together with the authors' names and affiliations. Although discussion relating to the individual presentations was encouraged and some of the comments are included in the text of this report, the contents of the individual abstracts were not discussed fully by the group, and as such they do not necessarily reflect the views of the WGFTFB.

6 Mini-symposium: Technology Development and Sustainable Fisheries

Chairs:

Pingguo He, University of Massachusetts Dartmouth (USA)

Petri Suuronen, FAO Fishing Industry Servies (Italy)

Juan Carlos Seijo, Merista University of Merida (Mexico)

6.1 Introduction

The meeting was opened by greetings from Francisco Espinosa, Director of Research, Marista University of Merida, the host university. On the podium were M.I. Miguel Baquedano Pérez, Rector of Marista University of Merida, Juan Carlos Seijo, Professor of Fisheries Bioeconomics, School of Natural Resources, President of the University Board of Governors, Marista University of Merida, Petri Suuronen, Fishing Industry Officer, FIRO, FAO, United Nations, and Pingguo He, Professor of Fisheries, School for Marine Science and Technology, University of Massachusetts Dartmouth. Welcome messages and introductory remarks were followed by Suuronen, Professor He and Professor Seijo.

The mini-symposium contained six theme sessions:

1) Challenges and advantages in static fishing gears
2) Encouraging technological change in capture
3) Energy and greenhouse gas (GHG) reduction in capture fisheries
4) Technology and practice for managing bycatch and reducing
5) Innovative technologies for observing fish and fishing gear
6) Fishing technology to eliminate vaquita bycatch from fisheries in the Upper Gulf of California (UGC) - A Special session In corporation with World Wildlife Fund (WWF) and US Marine Mammal Commission (MMC).

The two-and-half-day symposium included 40 oral presentations and 14 poster presentations, and was attended by 85 scientists from 23 countries across four continents (Europe, North America, South America and Asia).

This mini-symposium represents an opportunity for WGFTFB to meet its goals of providing a forum for global synthesis of scientific knowledge of fishing technology, fish behaviour, and their application in conservation and sustainable utilization of world's marine resources. The two-and-half-day symposium is intended to advance our knowledge of the subject matter and to draw upon the unique regional expertise in South and Latin America.

The abstracts of all presentations are included in the following sections (* indicates presenting author in multi-authorship abstracts. Only presenting author's e-mail address is provided). The PowerPoint presentations are included as an appendix.

6.2 Challenges and Advantages in Static Fishing Gears

Facilitators:

Daniel Aguilar-Ramirez, Instituto Nacional de Pesca (Mexico)

Pingguo He, University of Massachusetts Dartmouth (USA)

Selecting from alternative fixed gear technologies under behavioural uncertainty: A decision theory approach

Keynote presentation

Juan Carlos Seijo

Universidad Marista de Mérida, Periferico Norte Carretera Merida-Progreso Merida Yucatan 97300, México (jseijo@marista.edu.mx)

Recent technological development in marine fisheries include fish species identification technologies, biomass estimation technologies, changes in gear retention efficiency, changes in species and size selective gear, and minimizing bottom-trawling gear effects on benthic habitat, and bycatch. Selecting among alternative technologies for improving species and size selectivity of fixed gear, involve uncertainties associated to fish behaviour (i.e. reproductive, feeding, migratory, predation survival, and cognitive behaviour), and fisher behaviour (i.e. compliance with new gear regulations, among other possible behavioural responses). A decision theory approach with and without probabilities of occurrence of states of nature (associated to fish and fisher behaviours) is presented and discussed for selecting among alternative technologies.

Fishing efficiency and bycatch rate of whelk trap depending on the shape of trap and net materials in the Uljin waters, Korea

Heui-Chun An

National Institute of Fisheries Science, 216 Gijanghaean-ro, Gijang-eup, Gijang-gun, Busan 46083, Republic of Korea (anhc1@korea.kr)

Whelk trap fishery is one of the important fisheries in the eastern coast of Korea. There are bycatch and discards problems in the whelk trap fishery because they use bait to attract whelk. We carried out experiment to estimate catch efficiency of target species, bycatch and discards situation of whelk trap in accordance with the shape and net material of whelk trap.. Field experiment was conducted from July, 2014 to August, 2015 in the Uljin waters, East coast of Korea. Two different shape of traps, cylinder type and drum type, and three different materials, biodegradable material, PE and PA were used. This presentation will introduce fishing efficiency, bycatch rate of whelk trap depending on the shape and net materials of trap and the feasibility of commercialization of biodegradable material for whelk trap fishery.

Can we develop species selective fisheries using salmon pontoon traps?

Peter Ljungberg*, Sara Königson, Sven-Gunnar Lunneryd, Maria Hedgärde

Swedish University of Agriculture Science, Institution of Aquatic Resources, Turistgatan 5 Lysekil Västra Götalands län S-45330, Sweden (* peter.ljungberg@slu.se)

Small-scale coastal fisheries in Sweden are decreasing with increasing seal populations. In addition, the introduction of EU's landing obligation makes the situation for coastal fisheries even more complex. A stronger focus on the advancement of both selective and seal-safe gear is therefore of great importance to sustain coastal fisheries. In Sweden, a total of 300 pontoon traps are used in the salmon (*Salmo salar*) and whitefish (*Coregonus lavaretus*) fisheries. While protecting the catch from seal, they have until recently lacked the possibility of releasing live bycatch without first collecting the catch. With the use of a "hose-net", a codend which can be equipped with suitable mesh size, the fish may be sorted by the fisher without having to be lifted out of the water. The use of a hose-net has been shown to drastically decrease handling-inflicted damages in the fish. Besides a small number of fish displaying single scale loss, our field trials showed that only one salmon out of a total 182 got stuck or damaged in the hose-net during the collecting process. Our results show that with the use of a hose-net, in regards selection panels, to allow for a gentle and selective process of releasing non-target species and size classes, which meet the landing obligation. The advantages of the hose-net in the salmon fisheries calls for further development and its application in other fisheries. At the moment one of our challenges is a size selective pontoon trap in the costal cod (*Gadus morhua*) fisheries.

Behavioral observation of young bluefin tuna *Thunnus orientalis* and yellowtail *Seriola quinqueradiata* in the set-net using an ultrasonic biotelemetry

Keiichi Uchida*[1], Kohei Hasegawa[1], Hiromichi Ogawa[1], Seiji Akiyama[1], Hideki Noro[2], Yoshinori Miyamoto[1]

1. Tokyo University of Marine Science and Technology, 4-5-7 Konan, Minato-ku, Tokyo 108-8477, Japan (* kuchida@kaiyodai.ac.jp)
2. Horiei Inc. Co.

If the difference in behaviour of young bluefin tuna *Thunnus orientalis* and other fish species in the Japanese set-net, there is a possibility that can be released only young bluefin tuna. For this purpose, the behaviours of fish are necessary to be clarifying inside the net. In this study, using an ultrasound biotelemetry system, and tried to clarify the behaviour in the set-net of young bluefin tuna and yellowtail *Seriola quinqueradiata*. It was carried out observation in June 2015 in the large set-net of Aomori Prefecture, Japan. Installation type ultrasonic receivers (AQRM-1000, AquaSound Inc.) were installed to the four corners surround the first and the second bag net, one receiver was installed to center of the slop funnel during the first and the second bag net. Ultrasonic transmitters (AQPX-1040PT, AquaSound Inc., 9.5 mm of diameter, 43 mm of length) were attached near the dorsal fin of tuna and yellowtail using the hook. One of tuna was moved from the second bag to the firs bag in about 1 h after release. Comparing the swimming behaviour of both species, there was not a large difference in the swimming depth. Yellowtail swim along the net, tuna tend to swim a little away was seen from the net. By utilizing these differences of action, it is believed that there is a possibility that the divided catching both.

Observations of fish behavior in and around passive fishing gear: an efficient tool in fishing gear development

Peter Ljungberg[1] Sara Königson*[1] Maria Hedgärde[1], Lotte Kindt-Larsen[2]

1. Swedish University of Agriculture Science, Institution of Aquatic Resources, Turistgatan 5 Lysekil, Västra Götalands län S-45330, Sweden (* sara.konigson@slu.se)
2. DTU Aqua, Technical University of Denmark, Jaegersborg alle 1 Charlottenlund Denmark 2900

Cod pots are fishing gear that has been under development for many years in the Baltic Sea. The main reason for implementing cod pots in this area is to mitigate the severe seal fisheries conflict in the area. Cod pots are baited fishing gear and biotic and abiotic factors affect the pots catch efficiency. One factor that needs to be taken into regards is the behaviour of the fish in relation to the fishing gear. Easy accessible and affordable camera techniques allow long-time in situ studies of fish behaviour. By filming cod pots for at least 24 hours, we will try to answer questions such as how different models of pot entrances affect the fish´s ingress and escape behaviour and if there is a saturation effect i.e. if the numbers of escapes actually increase with the number of fish enclosed in the pot. Many models of cod pots have been constructed with holding-chambers to prevent fish from escaping. A holding-chamber prevents fish from escaping if the pot has an open entrance. A holding camber might also prevent potential saturation effect and stop fish from gathering in the entrance-chamber and thereby stopping other fish from entering the pot. We have studied the ingress behaviour of cod entering pots with different entrances and their behaviour inside the pot in order to find out if the holding–chamber is increasing the pots catch efficiency. The results from the behaviour of cod will be related to catch results from test fishing carried out simultaneously.

Development of cod pots as fishing tool to solve the conflict with seal depredation and harbour porpoise bycatch

Lotte Kindt-Larsen*[1], Maria Hedgärde, Casper Willestofte Berg[1], Finn Larsen[q], Sara Königson[2]

1. DTU Aqua, Technical University of Denmark, Jaegersborg alle 1 Charlottenlund, Denmark 2900 (* lol@aqua.dtu.dk)
2. Swedish University of Agriculture Science, Institution of Aquatic Resources, Turistgatan 5 Lysekil Västra Götalands län S-45330, Sweden

The conflict between gillnet fisheries and the growing seal populations in Baltic Sea has increased considerably in the recent years and direct damages in form of reduced or damaged catches have been observed. Opposite is the conflict between the critically endangered Baltic harbour porpoise and their risk of bycatch. In order to both conserve a sustainable fishery and avoid the risk of porpoise bycatch a project was initiated to develop cod pots, as these can be protected against raiding seals and do not have porpoise bycatch. The project was collected in the Danish part of the Baltic Sea. The first trial had forty prototype cod pots, ten each of four types, where the second trial had seventy prototypes, ten each of seven. All pots were deployed in a random setup and hauled daily for one month. The trials tested how catch rates were affected by (1) floating or bottom deployment, (2) size/volume, (3) rearrangement of catch cambers to vertically instead of horizontally or left out, and (4) how a "sun" entrance design influenced catch escape. The results revealed that bottom-set pots caught significantly ($P = 0.05$) more cod compared to floating pots. Second, an effect of size were only found in bottom standing pots as the size in bottom standing pots could not be reduced without affecting the catch rate. Third, no effects in catch rates were found by placing the catch camber vertical or by removing the catch camber, and fourth, no effect of the "sun" entrance design was found.

6.3 Encouraging Technological Change in Capture Fisheries

Facilitators:

Steve Eayrs, Gulf of Maine Research Institute (USA)

Michael Pol, Massachusetts Division of Marine Fisheries (USA)

What role can organizational change management play in encouraging change in capture fisheries?

Keynote presentation

Steve Eayrs

Gulf of Maine Research Institute, 350 Commercial St., Portland, Maine 4101, USA (steve@gmri.org)

This presentation is based on a study to explore the application of organizational change management in the commercial fishing industry, to identify why past change initiatives were unsuccessful, and to help future change initiatives. This study invited fishers in North America and Australia to respond to a questionnaire regarding their appetite and attitudes to change, including The Paradox of Fishers. Each fisher was involved in an industry group that facilitates change on their behalf. Another questionnaire invited WGFTFB members to provide their perspective regarding the appetite and attitudes of fishers to change. Responses were received from 54 fishers and 47 WGFTFB members. Loss of control, mistrust, and lack of reward were the dominant reasons fishers gave for their reluctance to change. WGFTFB members primarily believed it to be due to concerns over cost and lack of incentives. The ramifications of these differences are discussed. Support for The Paradox of Fishers was found, but also evidence it may be a misunderstanding by WGFTFB members. The performance of each industry group was evaluated. Fishers predominantly joined each group because of an urgent need to change, although there was disagreement regarding remedial action. Fishers indicated that each group poorly communicates its vision to change and inadequately supports behaviour consistent with the vision. No evidence was found that change management models were used by any group. A new organizational change model for application in fishing industry is presented, one that provides guidance to institute change, including enhanced ecological, economic, and social outcomes.

Health and socio-economic effects of hookah diving fishing technology in small-scale fisheries: A qualitative risk assessment

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Hookah diving is a fishing method and gear used in many small-scale fisheries in the Gulf of México and Caribbean Sea, as well as in many coastal fisheries around the world. Many of the high value species like sea urchin, sea cucumber, queen conch, spiny lobster, mussels, and clams, among others are harvested worldwide with hookah diving. Decompression sickness and carbon monoxide poisoning are diseases related to hookah diving and are the cause of disabilities and death among small-scale fishers with the social and economic effects over households and coastal communities. There is still misunderstanding among fishers concerning hookah diving risks. This study reports on a qualitative risk analysis method developed to obtain fishers perception of likelihood of undesired health threatening events occurring as a result of hookah diving, and the corresponding perceptions of impacts or consequences of such accidents. These risk perceptions are contrasted to actual hookah accidents occurring in the spiny lobster and sea cucumber small-scale fisheries in two ports of northeastern Yucatan coastal area. The method allows for identification of priority decisions relevant to the need for appropriate fishing technologies, for fishers capacity building associated to health related precautionary measures, and increased community awareness of possible consequences of current fishing technology.

Industry-led fishing gear selectivity improvements. How can we increase flexibility and ownership over the gears used while ensuring an effective introduction of the new EU Common Fisheries Policy?

Jordan Feekings[1], Ludvig Krag*[1], Tiago Malta[1], Henrik S. Lund[2], Søren Eliasen[3], Clara Ulrich[1], Lars Mortensen[1]

1. Technical University of Denmark, DTU-AQUA Jaegersborg alle 1 Charlottenlund Denmark 2900 (* lak@aqua.dtu.dk)
2. DFPO
3. IFM, Aalborg University

With the reform of the European Union (EU) Common Fisheries Policy (CFP), and the introduction of a Landing Obligation, the ability of fishers to adjust the selectivity of their gears to suit the quotas which are available to them will be an important factor in determining the revenue and rentability in the fishery. As the combination of gear, fishing practice and quota shares will differ between vessels, changes to the selectivity of the gears will need to be implemented at the vessel level and based on the quotas which are available to the vessel at a given time. For this to be realized, simple and cost-effective solutions which can be quickly coupled with existing gears will be in demand. These solutions will need to be implemented quickly in order for them to solve the issues at hand without losing substantial income. Furthermore, these solutions will need to be scientifically tested to document their effect before being considered for implementation into the legislation. This project aims to establish a scheme comprised of stakeholders (fishers, netmakers, producer organizations, and scientists) with the intention to promote the development of ideas and solutions originating in the industry. It is anticipate that the problems encountered during the implementation of the reformed CPF will not be the same for all fishers and hence the solutions required to tackle these problems will also differ. Furthermore, solutions will need to be found relatively quickly before financial difficulties become too severe. Therefore, the scheme aims to facilitate and fast track the testing of new designs proposed by stakeholders and their implementation in legislation. Here we present the projects structure, the methods used to test ideas coming from the industry, as well as how successful solutions can be potentially fast-tracked through the legislative process.

Improving tropical shrimp fisheries through eco-labelling: experiences from the Suriname seabob fishery

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Tropical shrimp trawl fisheries remain the main supplier of shrimp to the global market, but face many environmental and socio-economic problems and challenges. The negative public perception of tropical shrimp, and the increasing market demand for sustainable seafood products has triggered the fishery for Atlantic seabob shrimp *Xiphopenaeus kroyeri* off the coast of Suriname to take steps towards more environmentally sustainable fishing practices. A pre-assessment against the principles and criteria of the Marine Stewardship Council (MSC) certification scheme identified the main issues in the fishery, which were tackled by a two-year improvement program. This included an overall reduction in fishing effort, spatial fishing restrictions, installation of VMS on all trawlers, stock assessment and the development of a Harvest Control Rule, and mandatory use of Bycatch Reduction Devices, in addition to the Turtle Excluder Devices. Further, to seek consensus on management measures, a monthly stakeholder meeting was installed, bringing together representatives from the government, the fishing industry, the artisanal fishing sector and an NGO. The improvement process was initiated by the fishing industry, seeking MSC certification, but was executed in cooperation with the Suriname government, who consolidated the improvement process into a legally binding management plan for the fishery. In 2011, the Suriname seabob fishery obtained an MSC certificate, as the first and still one of the only fisheries of this kind. The experiences from Suriname show that eco-labelling initiatives might successfully bring about change and trigger an ecosystem approach to management in tropical shrimp trawl fisheries.

VALDUVIS: An innovative approach to assess the sustainability of fishing activities

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The Belgian fishing sector is under pressure to demonstrate the sustainability of its fishing methods. First, the beam trawl (which accounts for 80% of the landings) is contested due to its low selectivity and significant disturbance of the seabed. Second, the Belgian retail market has committed to sourcing sustainable seafood. However, converting to sustainable methods is costly and may not be feasible for the majority of fishers who have suffered economic losses in the wake of the 2008 fuel crisis. Instead of a full-scale transition to sustainable fishing, fishers have developed modifications to the beam trawl that reduce environmental impact and save fuel. We propose an indicator-based sustainability assessment tool (VALDUVIS) that recognizes these efforts and offers incentives for fishers to adopt more sustainable fishing practices. In this article, we describe the development of the tool and its potential applications. Integrated Sustainability Assessment (ISA) was used as a framework to develop the tool and to initiate the transition towards sustainability in the Belgian fishery. VALDUVIS offers a promising new method to assess sustainability in fisheries. The approach is innovative in several ways. First, indicator scores are calculated using official data flows (e.g. the electronic logbook), which enhances traceability and provides the possibility of communicating sustainability data soon after landing the fish. Second, indicators are scored on a fine scale (e.g. per fishing trip). Third, stakeholder participation was essential in the development of the tool. This enhanced the support of the wider fishing sector and assured the relevance of the indicators and the users' understanding of the tool. Fourth, the delivered tool is multi-purpose and can be easily adapted to the needs of a range of end-users (fishers, wholesalers, retailers, authorities, researchers, etc.). The VALDUVIS tool offers a cost-effective alternative to known certification schemes that could be applied to any type of fishery. The Belgian fishing sector considers VALDUVIS to be suitable for monitoring the progress towards sustainability as well as for providing incentives for fishers to adopt better practices.

Fishing gear related to octopus behavior in the Octopus maya fishery of Yucatan shelf

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For over 30 years, the artisanal octopus fishery in the Yucatan shelf has been assessed to operate in the neighbourhood of MSY. Artisanal fishers target *Octopus maya*, an endemic species with a particular behaviour. Few octopus species in the world have a similar breeding behaviour; after females lay the eggs, they stay near the eggs cluster, aerating and caring it. During the developmental process, females do not feed and die of starvation one week after eggs hatch. The fishing method used in the Yucatan shelf to fish for octopus consists of a rod with lines having crabs as bait and weights with no hooks. Since this method provides food (fishing with bait, i.e. crabs) instead of habitat (fishing with pots or traps), even when part of the fishing season takes place during reproduction periods, it protects spawner females from being harvested and therefore allows for sustainable generations of recruits, given the relatively strong stock–recruitment relations calculated. The sustainable yield has been estimated in 11 000 tonnes per season, from August to December; however, in some seasons the catch has overpassed the 18 000 tonnes. Along with the fishing method related to the octopus breeding behaviour and because the short lifespan of the species, the closure season for fishing of eight months, allows to an entire generation to reproduce to maintain the fishery and the natural population. In this study, we present evidences about the female – male proportion in the landings, the maturation process, and the population structure that confirms that the fishing gear related to the breeding behaviour of the species has been a key factor to maintain this important fishery for the region at sustainable levels.

6.4 Energy and Greenhouse Gas Reduction in Capture Fisheries

Facilitators:

Antonello Sala, National Research Council (Italy)

Liuxiong Xu, Shanghai Ocean University (China)

Emerging issues on energy use in fisheries and development of low impact and fuel- efficient gears

Keynote presentation

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As an industry, the provision of seafood and other aquatic food products compares well with other proteins with regard to its emissions of greenhouse gases. However, there is no room for complacency and there is growing industry recognition that there will always be room for improvement in this area, right across the supply chain. In response to this, the British Standards Institution, with the support of seafood industry representatives, has brought together an international group which includes representatives drawn from many areas of the world with strong fishing and aquaculture interests, to establish a common approach for the industry to assess its GHG emissions and allow informed action to reduce those emissions globally and locally. This group has gathered and shared current knowledge of emissions from fisheries and aquaculture production units across the world and developed a common understanding of the aquatic food products industry, leading to a broad consensus on how greenhouse gases from seafood and other aquatic food products can best be assessed, using the methodology provided by PAS 2050:2011. This Publicly Available Specification (PAS), PAS 2050-2, contains requirements for the assessment of life cycle greenhouse gas (GHG) emissions specifically associated with seafood and other aquatic food products. The requirements are supplementary to those specified in PAS 2050:2011, which provides a generic method for assessing the life cycle GHG emissions of goods and services. The purpose of this PAS 2050-2 is to provide supplementary requirements and additional guidance to seafood and other aquatic food products, by providing: a fisheries and aquaculture focus for aspects of the PAS 2050:2011 assessment; rules or assessment requirements that are directly relevant to the main sources of emissions from capture fisheries and aquaculture; clarity on how to apply specific elements of the PAS 2050:2011 assessment within the seafood sector. PAS 2050-2 provides a common and comprehensive method for the reliable, repeatable assessment of GHG emissions from the whole life cycle of seafood and other aquatic food products. The supplementary requirements provided relate only to the cradle-to-gate stages of the life cycle, where in this case cradle-to-gate includes distribution until the product reaches the retailer, food service or similar gate. It is hoped this standard shall help industry stakeholders appreciate different perspectives on assessing greenhouse gas emissions in aquatic food, identify areas of consensus and establish a common approach.

Application and review of energy audit protocols in the commercial fishing industry

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While global oil prices have declined substantially in recent years, now is an opportune time for commercial fishers to invest in fuel conservation technology in anticipation of future increases in oil price. This technology not only reduces reliance upon limited fossil fuels, but it contributes to a reduction in greenhouse gas emissions and helps maintain the profitability of fishers during periods of high oil price and/or low landings value. An energy audit is an important early step toward evaluating the potential impact of fuel conservation technology in fisheries, including their suitability and relative contribution to fuel conservation. This paper describes the application of energy audit protocols in the New England groundfish fishery (USA) and the Thai multispecies trawl fishery. It provides first order estimates of fuel saving based on a suite of vessel and fishing gear options available to fishers, including estimated payback (amortization) periods, and it describes a number of limitations and pitfalls to be avoided when conducting an energy audit of commercial fishing boats.

Efficientship: fuel saving in fisheries through heat recovery from main engine – a case study in Ireland

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Energy efficiency is a keyword in modern fishing industry, being a basic factor of competitiveness, sustainability and for protection of the environment. Fuel efficiency affects environment, causing pollution due to GHG and particulate emissions, directly related to the amount of fuel used. The ORC (Organic Rankine cycle) technology is an innovative solution, which converts waste heat from thermal engines into electricity, and it is currently increasing its applicability as an energy-saving application. The purpose of this study is to describe the technical evaluation and the economic assessment of the implementation of an ORC system onboard fishing vessel in Ireland. An innovative patented ORC system was integrated in proprietary ORC module, consisting in a high performance micro-turbine, able to convert low and medium temperature waste heat into electricity with high efficiency. The energy profile of the vessel has been defined, based on information collected onboard during a technical inspection. On the basis of the energy demand, a technical plan has been conceived, based on the recovery of heat from the main engine, to produce electricity for energy supply of three water pumps, normally by auxiliary engines. The reduction in such diesel engines usage could represent a relevant fuel saving, up to 10%. The methodology adopted for the technical and economic feasibility is reported.

6.5 Technology and Practice for Managing Bycatch and Reducing Discards

Facilitators:

Petri Suuronen, FAO Fishing Technology Services (FAO)

Julio Garcia, INIDEP (Argentina)

Mario Rueda, Marine and Coastal Research Institute - INVEMAR (Colombia)

Effort to minimize unwanted bycatches in the North-East Atlantic trawl fisheries: A brief summary of the developments over the last 40 years and current status

Keynote presentation

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Of all fishing methods used in the North-East Atlantic (NEA), the small-meshed trawls used for targeting the deep-water shrimp *Pandalus borealis* were especially known for their high volume of bycatches, including large numbers of juveniles from commercially important species. Attempts to reduce bycatches of unwanted (and illegal) catches of small fish or undersized shrimps from shrimp trawls started in Norway 43 years ago. Until the end of the 1980s we mainly worked on soft excluder panels, square mesh codends or various trawl designs trying to utilize the differences in behaviour between fish and shrimps. By 1987, a discard ban was introduced in the NEA as a result of a dramatic negative development in the important cod fisheries. It led to a clear shift in the Norwegian-Russian management of the NEA fisheries. The joined Norwegian-Russian fisheries commission acted fast to seek practical solutions and (again) the bottom-trawl fisheries were in the spotlight. Together with representatives from the Directorate of Fisheries and the fishing industry, a group of researchers started to identify the bycatch problem and the scale of it. In an attempt to mitigate the bycatch problem in the Norwegian coastal (inshore) fisheries the idea of the Nordmöre grid was born in 1989. A year later, it was made compulsory in the fishery. A similar development was made with fish trawls during the start of the 1990s, but the use of rigid grids in the NEA trawls targeting codfish was made compulsory later (1997). The success of the Nordmöre grid spread fast to countries like Iceland, Canada, Faroe Islands, Greenland and USA, and later to Australia and Argentine. Today, more than 25 years later, we still use exactly the same type of grids as the main technical solutions to control levels of bycatch in the NEA trawl fisheries.

Employing a trawl independent multi-compartment towing rig to study selectivity of crustaceans in trawls

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Observations of fish behaviour demonstrate that for most species the main size selection occur in the codend. Fish display “herding behaviour” by avoiding the trawlnetting during the catching process. Small crustaceans are regarded as less mobile compared to most fish species and size selectivity are thus, more associated to a sieving process with less active avoidance from the trawl panels. Crustaceans likely experience multiple netting contacts during their passage towards the codend. Trawls used for catching small crustaceans, e.g. Pandalidea and Euphausids are often with a low tapering design. Traditional net selections studies using collecting bags or similar systems for collecting escaping individuals are difficult to use in low tapered trawls due to the high risk of masking, which prevent organisms to enter the cover bag. Also full-scale selectivity experiments to estimate full gear selectivity are both complicated and highly resource demanding. In this study, we develop and test a trawl independent towing rig designed to investigate size selectivity of Antarctic krill (*Euphausia superba*) in trawlnetting with commercially used size. The towing rig was designed with a specific and sequential arrangement composing of similar size compartments to quantify the proportions of individuals that; encountered the netting, encountered the netting and escaped, and encountered the netting and did not escape. These results demonstrate that valid selectivity estimates, equal to experimentally derived results, can be obtained using the multi-compartment towing rig. These findings indicate a potential for developing simpler and especially more cost-effective ways of both investigating and estimating selectivity of small crustaceans.

Technology on board to improve discards survival on Basque purse-seine fishery

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The landing obligation stated in the article 15 of the EU regulation No 1380/2013 in the Common Fisheries Policy considers some exemptions to the general rule, being one of these exemptions the one that refers to the high survival rates of the discard. According to this exemption, some experiments were carried out in the Basque purse-seine fleet in regular commercial fishing conditions. The discard on this fleet is not well known but some species like mackerel or horse mackerel, frequently making up mixed schools could be discarded due to quota exhaustion. The objective of the experiments was to assess the survival rate of the discard in this fishery. The purse-seine gear, due to its technical characteristics and way of use, is one of the most successful techniques when it comes to the survival of discarded fish. During the experiments, fish were put on board using a vacuum pump, and next a grading machine was used for the quick selection of the catch. With these two pieces of equipment, the fish are handled much more quickly than in traditional manoeuvre where big brailers are used. Afterwards a fraction of the fish was introduced in tanks on board simulating the discard to the sea. The tested species were mackerel, horse mackerel, anchovy, sardine, and Spanish mackerel. Results obtained show promising survival rates in some fishing condition.

Reduction of the shrimp bycatch from tropical trawling on the Colombian pacific

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Quantification of the tropical shrimp trawling impact and mechanics to reduce it on the Pacific Colombian coast was evaluated as part of the REBYC I project between 2004 and 2006. The methodological approach included census of the fishing technology, monitoring, workshops, trials and experiments. The census revealed that vessels and net designs are > 30 years old. Fishing monitoring showed the following catch composition: shrimp is 5%, incidental catch is 43% and discards are 52%. In this sense, new trawlnets were designed introducing new netting materials and BRDs (fish-eye and TED). Six trawlnets prototype were manufactured during two workshops, where 30 fishers were trained in fishing trials. These trawlnets were used in fishing experiments comparing catches of an experimental vessel (using prototype nets) with those of a control vessel (using traditional nets) to test reduction of bycatch and fuel consumption if possible. 240 experimental hauls showed reductions ranging from 23% to 57%. The fuel saved was 25%. Current decrease of the shrimps stocks and high fuel prices, are part of the issues that the fishery management agency in Colombia faces to change of management; however results of the project has not been implemented still.

Iluminated area in front of a topless trawl in order to reduce bycatch in shrimp fisheries

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Bycatch and discards in shrimp fisheries are a common and a worldwide problem. In some years, high level of 0-group gadoids is present in the Icelandic inshore fisheries of *Pandalus Borealis*. By regulations, fishing areas are closed if the level of juveniles exceeds certain limits. In the offshore shrimp fisheries, a Nordmore grid is used to exclude catch of undersized fish. That system, however, is not working properly on the inshore grounds, as the 0-group (cod and haddock mainly) is not sufficiently filtered out simply because it is too small. Another issue is that seaweed is clogging the grid causing substantial loss of marketable shrimp. This presentation describes an ongoing research project where the selection of three different shrimp trawls is compared, i.e. a conventional one with codend cover (control), conventional trawl with 19 mm Nordmore grid, and a modified topless trawl with light on the footrope bosom. Some of the preliminary results are presented and future aspects of the project discussed.

One step beyond: identification of 'improved selectivity' using selectivity experiments and population models for brown shrimp (*Crangon crangon*) beam trawl fishery in the North Sea

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High rates of undersized brown shrimp (*Crangon crangon*) are caught and discarded in North Sea beam trawl fisheries due to the poor selectivity of commercial codends. Therefore, a project was conducted to improve the size selectivity of codends in this fishery to give advice on technological improvements towards sustainable exploitation patterns. In contrast to previous research projects, the project 'CRANNET' not only determined the size selectivity of a wide range of codend designs (36 codend designs; netting orientation: T0, T45, T90; mesh size: range between 15 mm and 36 mm). Moreover, the optimal codend designs were identified based on the influence of selectivity on population dynamics and resulting commercial catches of the fishery, using population and economic models. The presentation gives a detailed overview about selectivity results for shrimp and bycatch species. The models presented in this study can be used as predictive tools to simultaneously adapt the mesh orientation and mesh size of commercial codends to meet specific necessities of the fishery. In addition, the influence of size selectivity, and timing of introduction of new codends on population dynamics and commercial catches will be presented. The presented work will give an example for a new way to identify "improved selectivity" for a given fishery, not only focusing on e.g. reduction of discards.

Using fish behaviour to separate fish from Nephrops in a horizontally divided codend in the mixed trawl fishery

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A major challenge in mixed fisheries is to obtain acceptable size selectivity of the species caught, which may vary in size, shape and behaviour, e.g. *Nephrops* (*Nephrops norvegicus*) and cod (*Gadus morhua*). Horizontally divided trawls create the opportunity of having different selective properties in upper and lower compartments. To obtain full selective effect, fish have to be caught in the upper compartment and *Nephrops* in the lower. Based on knowledge of vertical distribution of fish in trawls, a horizontally divided codend with small square meshes (40 mm) was tested for its ability to separate seven commercial fish species from *Nephrops*. A simple frame was inserted at the entrance to the lower compartment to stimulate fish to swim into the upper compartment. A significant length dependent distribution where small individuals were caught in the lower compartment and large ones in the upper was found for cod and whiting (*Merlangius merlangus*). Haddock (*Melanogrammus aeglefinus*) and saithe (*Pollachius virens*) had a significant preference for the upper compartment while the same was true for hake (*Merluccius merluccius*), plaice (*Pleuronectes platessa*), witch flounder (*Glyptocephalus cynoglossus*) and *Nephrops* for the lower compartment. These results demonstrate that it is possible separate the majority of gadoids in from the vast majority of *Nephrops*. Thus, there is a potential of improving size selectivity in mixed fisheries considerable using a vertically divided codend.

A global analysis of cetacean bycatch and mitigation measures

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WWF and CMS have joined efforts with Damon Gannon to compile a comprehensive literature review of the characteristics of each fishery known to cause cetacean bycatch, that will include: Fishery Name; Country; Target Species (common and scientific names); Bycatch Species (common and scientific names); Gear Type (gillnet/longline/trawl/purse-seine); Economic Status of Country (developed/developing); Socio-economics of Fishery (artisanal, semi-industrial, industrial, or recreational, as defined by the FAO); Fishery Management Authority (local governance/stakeholder management/national governance/governance unclear); Initial Cetacean Stock Size (prior to any mitigation measures); Certainty of Cetacean Stock Size Estimates; Initial Bycatch Estimate (prior to any mitigation measures); Certainty of Bycatch Estimate; Gear Characteristics (mesh size and twine size or hook size and hook characteristics, gear dimensions, depth of gear, gear weight); Vertical Location of Gear (pelagic/demersal), Horizontal Distribution of Gear (estuarine/near coastal/shelf/oceanic); Mitigation Strategy; Degree of Success (strongly successful/moderately successful/no change/exacerbated problem/unclear); Cost; Brief Explanation (including information on how strategy was developed and implemented); and Literature Citations. If sufficient information is available, statistical meta-analyses using logistic regression and/or classification and regression trees (CARTs) will be performed for each of the four primary gear types (gillnet, longline, trawl, purse-seine) to identify the conditions under which bycatch mitigation is most likely to succeed. Finally, a decision tree will be created to assist fishery managers and environmental policymakers to reduce cetacean bycatch in specific fisheries. The report will be completed by Gannon, revised by WWF and CMS technical experts, and finalized for results to be presented for the first time at the ICES-FAO FTFB Symposium.

Development of a turtle releasing system (TRS) for set-net fisheries

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This study presents a turtle releasing system (TRS) for a set-net. The set-net fishery is a major and important coastal fishery in Japan, and the set-net occasionally catches sea turtles in some coastal regions. Sea turtles straying into the fully submerged bag net of the set-net are often drown because the upper panel of the bag net blocks the turtles from swimming up to the surface to take breathes. The set-net is not a mobile gear like a trawl but a stationary fixed gear, and thus sea turtles have to go out of the set-net spontaneously. Sea turtles in the closed net start pushing their heads up against the upper panel when they want to take breaths. The TRS has been developed for allowing turtles to escape from the fully submerged bag net. This system consists of a turtle releasing device (TRD) and about 20 degrees sloping (quadratic-prism shaped) upper panel of the bag net. This sloping upper panel induces the turtle moving to the shallower and then guides it to the TRD installed at the top of the upper panel. In the tank experiments, the loggerhead and green turtles moved to the top of the upper panel with pushing up, and escaped out from the bag net through the TRD successfully. Sea trials were also performed in TRS-introduced submerged bag net (30 m x 10 m x 10 m) of the set-net with loggerhead turtles, and the turtles were managed to escape out of the net successfully.

Avoidance of Atlantic cod with a topless trawl in the New England groundfish fishery

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Atlantic cod *Gadus morhua* stocks in New England are at historic low levels of biomass, and fishers must avoid catching them to continue fishing on other stocks. "Topless" (or "cutaway" or "coverless" or "pineapple") trawls, where the headline is > 30% longer than the fishing line, have been tested in the region and elsewhere to avoid cod and target flatfish. Loss of flatfish in those tests discouraged adoption. In this study, a modified topless trawl (headrope : footrope ratio of 1.71 : 1) was tested compared to a control net in paired comparisons. Cod catches were reduced over 50% on average across all sizes, without loss of flatfish catches, except smaller individuals of American plaice (*Hippoglossoides platessoides*). We discuss possible reasons for the improvement in flatfish retention in this design based on behaviour and net geometry and other benefits of topless designs.

Be FLEXible; a simple and cheap flatfish BRD concept for roundfish trawl fisheries

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The landing obligation, adopted in the reformed European common fisheries policy (CFP), represents a strong incentive for the industry to find ways to reduce bycatch volumes of quoted species. In the Baltic Sea, plaice (*Pleuronectes platessa*) has been identified as potential choke species for the German Baltic cod (*Gadus morhua*) trawl fishery. Besides, other unquoted flatfish species are taken as bycatch and subsequently discarded because of their low market value. With the aim of providing tools for the fishers to address the mentioned bycatch problem, different technological solutions have been recently developed. FLEX (FLatfish Excluder) is a simple, cheap, handy, and reversible adaptation of the net, which aims to exclude flatfish before entering in the codend. Experimental sea trials using a research vessel and paired gear method were conducted in November 2014 to test FLEX, resulting in ~ 80% flatfish bycatch reduction. As counterpart, catch losses in marketable length classes of cod were observed. Using these results as baseline, we further developed the concept with the aim of optimizing the performance of the first prototype. A total of 4 additional FLEX setups were tested in November 2015 in similar experimental conditions as in previous trials. Catch and operational covariates were taken into account in the experimental design and their potential influences in FLEX performance were assessed by regression tools. The best FLEX setup yielded a flatfish catch reduction of ~ 90% and no cod losses were observed. The simplicity in design and construction, and the results obtained in experimental test, point FLEX as one of the new developments with greater possibilities of adoption in commercial fisheries. The concept can potentially be transferred to other roundfish directed fisheries with flatfish bycatch problems.

Trials and tribulations of halibut bycatch reduction in Alaska's Bering Sea trawl fleet

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Halibut bycatch has been an ongoing issue in the North Pacific trawl fleet for more than 40 years, as have efforts and progress at reducing halibut bycatch rates. However, the urgency of those efforts has increased as recent halibut stock assessments have led to substantial cuts to halibut fisheries. In 2015, the quota for halibut bycatch in the Bering Sea/Aleutian Islands (BSAI) groundfish fisheries exceeded the quota for the directed halibut fishery. Several small native communities in the BSAI depend on that directed quota for their livelihoods. In order to help resolve this issue, in June of 2015, the North Pacific Fisheries Management Council, took final action to reduce halibut prohibited species catch (PSC), (AKA bycatch), by a total of 21% across four different fishing sectors. One of the sectors, the flatfish trawl fleet, had a 25% reduction in halibut PSC. The Conservation Engineering group at the Alaska Fisheries Science Center (AFSC) has been working cooperatively with several fishing gear manufacturers, fishers and fishing industry members to test various halibut excluder designs. This presentation will discuss the basic excluder design and the various versions currently in use, the challenges in understanding fish behaviour using video (e.g. mudcloud), the anecdotal data to date, and the problems with trying to exclude of similar size flatfish inside a bottom trawl. The presenter hopes to engage the experts at this meeting in a dialogue about the challenges associated with this halibut excluder to help move the project forward.

Flatfish survival assessment carried out in 2014–2015

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In the light of the EU landing obligation, the chances of survival were studied of sole, plaice and dab in the Dutch demersal fisheries. One of the objectives was to determine the average survival rate of sole, plaice and dab discards in commercial pulse and twinrig fisheries of the Dutch fleet. This was executed by monitoring fish collected from catches for a certain period of time (21 days on average) to observe fisheries-induced mortality. A second goal of this study was to investigate whether a vitality score can be used as a proxy of the survival chance. The vitality of each fish was assessed individually by scoring external damages and the impairment of reflexes, and related to the observed survival time. A third goal was to study the variation in discard survival estimates by looking into correlations between survival estimates and environmental or other potential factors. In total eleven experimental trips were carried out onboard three different vessels in the North Sea in the period between November 2014 and October 2015, five of which were primarily dedicated to comparing techniques for improving survival. Live fish from the catch were collected from different locations in the processing line and at different times. All sampled fish were scored for external damages and reflex impairment, then tagged to allow individual monitoring over time. To observe and record the survival times, these fish were stored in a specially developed system of tanks filled with continuously refreshed seawater. Except for the first trip, all experimental trips were done with three of such tank systems. The tank systems were designed with restrictions in dimensions and weight to allow transport from the vessels to the IMARES laboratory in Yerseke, the Netherlands and monitor survival over an extended period of time. During storage onboard, fresh seawater was continuously supplied. During transportation, the circulation of seawater was maintained and air supplied. Fish status was checked and dead fish were removed daily during the monitoring period of some three weeks. To distinguish between fisheries-induced mortality and handling-induced mortality, control fish were used. These control fish were caught using a small vessel operating a shrimp trawl in short tows at low speed previous to the survival experiments and were treated in exactly the same way as fish from the catch. Overall the survival rates of discard sole (as determined after a monitoring period of 21 days on aver-age) on the vessels fishing with a pulsewing (12 m width) and a commercial towing duration (~ 125 minutes) varied between 8% and 48%, with an average of 31% over all trips. For short hauls (~ 60 minutes) the overall survival rate was higher (24–59%) with an average of 41%. The overall survival rates of discard plaice on the pulse vessel taken from commercial hauls of ~ 2 hours varied between 4% and 26% per trip with an average of 16%. Using a short tow duration (~ 60 minutes) in-creased this percentage, with an average of 39%. Dab was only sampled during one trip onboard a pulse vessel, so this dataset is very limited. The overall survival rate of discard dab in this trip was 15%. In the twinrig fisheries, the overall survival rate of discard plaice was investigated in two trips, with 10% survival on average (5% and 16% per trip). Dab was sampled once in the twinrig fisheries, with an overall survival estimate of 8%. Sole control fish showed good survival rates (~ 85%) in our experiment. Plaice controls suffered mortality a couple of days after arrival at the laboratory in Yerseke, around Day 12. Mortality of control fish is undesirable and may lead to discussions about the accuracy and reliability of the observed survival rates. After trip eight, a Vibrio infection in the tank system affected mortality in the control and experimental fish. However, by right-censuring these data, possible infection effects are excluded. The study showed that the overall discard survival rates are correlated with fish vitality. Vitality was measured in two distinct ways; by using a damage classification of A, B, C, and D, comparable with earlier survival research and as a summation of present damage scores and reflex impairment scores, divided by the total number scored damages and reflexes. Both showed a relation with the survival rate of discard plaice. Too few data were available for the species dab and sole to find a good correlation. However, the data suggest that a similar relation exists for sole discard survival. To confirm this a relation, more data should be collected, in which external factors are taken into account. The overall discard survival rate varied considerably between the trips, however, the conditions also varied to a great extent between trips. It should be noted that a full factorial design, in which all (potential) factors are tested individually was not made for this study. Such a design was practically not feasible, as multiple factors could not be controlled (such as weather), while other factors are very coherent (such as fishing location and fishing depth), and because of limitations in resources only a relatively small number of trips could be carried out. As a result, only a first explorative analysis was done to identify potential, influential factors. From this explorative analysis, it seems that water temperature, towing duration, fishing depth, and vessel are factors that are highly correlated with discard survival rates, but a full predictive model was not tested so far. Such a model could lead to better knowledge of the various factors causing the mortality of the fish, and hence, give insight in adjustments that will increase discard survival rates. Next to the study described above, a plaice discard survival study was performed in Belgium in 2015. Three different fishing vessels fishing with varying fishing gear types were studied. Here too, the relationship between vitality score and discard survival estimate was investigated. Both the Dutch and Belgian datasets were merged and analysed together. In total six different fishing vessels were included in the data: two pulsewings (NL), a sumwing using tickler chains (B), an Aqua-planing gear with chain mats (B), a beam trawler with chain mats (B) and a twinrig (NL). The width of the gear, except the twinrig, ranged between 4 m and 12 m. Engine power was more than 1000 hp for four vessels (GY57, GO31, GO23, Z483) while the remaining two vessels were so-called "Eurocutters" with an engine power of ~ 300 hp (Z201, O190). Survival rates for plaice varied from ~ 10% to ~ 50% per trip, with an average monitoring period of two weeks. The highest survival rate was observed on-board an Eurocutter, fishing with light fishing gears, in shallow, coastal waters with a towing duration of ~50 minutes. Compared with the Dutch survival estimates for plaice discards, the merged dataset showed relatively lower survival estimates for comparable (in towing duration, fishing depth and gear size) fishing gear. Both damage class and vitality score appeared to be good proxies for survival. Haul duration was an important factor affecting survival rate, with shorter hauls having higher survival rates in general.

Effects of environmental variables on bycatch rates of Acanthocybium solandri in waters near Cook Islands

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It will be beneficial to reducing the bycatch rate of wahoo (*Acanthocybium solandri*) to better understand the effects of environmental variables on wahoo. The data were collected in longlining surveys in waters near Cook Islands from September to November 2012. Data included: hook depth data, temperature, salinity, and chlorophyll-*a* concentration vertical profile data, operating parameters, and bycatch data of wahoo. Stepwise regression was used to develop the hook depth calculation model. Statistics and clustering analysis were used to analyse the effects of depth and temperature on wahoo bycatch rate. The salinity and chlorophyll-*a* concentration range with the high bycatch rate of wahoo was deduced based on the depth range with the high bycatch rate of wahoo. Results showed that the depth and temperature range with the high bycatch rate for wahoo was 40.0～79.9 m, and 26.0～27.9℃, respectively. The deduced salinity and chlorophyll-*a* concentration range with the high bycatch rate of wahoo was 36.30～36.90, and 0.070–0.243 μg/L, respectively. Results suggested that less hooks should be deployed in the depth and temperature ranges with the high wahoo bycatch rate to mitigate the bycatch of wahoo when fishing in the waters near Cook Islands.

Sustainable management of bycatch in Latin America and Caribbean trawl fisheries – transforming wasted resources into a sustainable future

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Shrimp trawling and other types of bottom trawling provide employment, income, and livelihoods for a large number of people in tropical and subtropical countries. However, in addition to targeted species, trawling also catches a considerable amount of other fish and marine life. Often a significant part of this bycatch consists of small-sized and low-value fish but it can also include juveniles of commercially important fish species as well as highly vulnerable animals such as sea turtles, sharks or rays. When bycatch is effectively managed and utilized, it can contribute to food and nutrition security and constitute an important source of food for local populations. However, when it is discarded, it may represent a significant loss of food and revenue. In Latin America and the Caribbean (LAC), progress has been made in reducing bycatch in trawl fisheries. Nonetheless, this bycatch still constitutes a challenge to the sustainability, which jeopardizes livelihoods and long-term food security. Today, measures exist to manage trawl bycatch. These measures can be adapted to specific fisheries and take environmental conditions and socio-economic considerations into account. To achieve sustainable trawl fisheries, a comprehensive and participatory approach focusing on shared management and the livelihoods of fishing communities is needed. The regional REBYC-II LAC project aims to reduce food loss and support sustainable livelihoods by improving the management of bycatch and reducing discards by minimizing bycatch and facilitating utilization of sustainable bycatch, thereby transforming bottom-trawl fisheries into responsible fisheries. The project seeks to safeguard both human and environmental well being through a comprehensive approach that targets policies and regulations, improves technology and management, and enhances bycatch value chains.

Underwater observations of fish behavior related to bottom-trawl codend in the Mediterranean

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Information on fish behaviour is important for selectivity as well as discard studies. In the present work bottom-trawl selectivity experiments using different codend meshes (40 mm diamond mesh - used in the past in the Mediterranean, 40 mm square - currently used, and 50 mm diamond mesh - potentially used) have been studied to describe fish behaviour inside and outside the codend. The covered codend method was used. Cameras were placed in the inner and outer area of the codend to record net condition and fish escaping through the codend to the cover as well as individuals remaining in the codend. Information related to species identification, activity, direction of motion and condition were recorded. Anchovy, sardine, red mullet, stripped mullet, horse mackerel, pickerel, and bogue remained very actively swimming during the one-hour experimental trawling periods. They also tried to escape in an upward direction, passed through the codend and remained actively swimming between the codend and the cover. However, other species such as hake and anglerfish did not seem to be very active in the trawl and many times were observed to be moribund. Differences in fish behaviour and the number of fish species identified between the different codends were also examined. Implications of these observations to fisheries management were also discussed.

6.6 Innovative Technologies for Observing Fish and Fishing Gear

Facilitators:

Daniel Stepputtis, Thünen Institute of Baltic Sea Fisheries (Germany)

Pingguo He, University of Massachusetts Dartmouth (USA)

A review of technologies for observing fish and fishing gear underwater

Keynote presentation

Barry O'Neill

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The development of size and species selective trawls and the understanding of fish behaviour in relation to fishing gears have long been a major focus of fishing gear technology research. To carry out these activities a range of methodologies and procedures have been developed to observe both fishing gears and the behaviour of fish reacting to them. These include direct underwater observation techniques, using both divers and remotely controlled towed vehicles and instrumented sea trials to measure the dimensions and engineering performance of fishing gears. Additionally in recent years, increased importance has been given to investigating the benthic impact of fishing gears. Again a range of techniques and instrumentation are being used and include particle size analysers, water sampler bottles, laser line metrology, high frequency accelerometers and force sensors and video and optical and acoustic systems. A brief overview of these instruments and techniques is given here. Some current developments, in relation to measuring the physical impact of fishing gears on soft sediments and some future prospects, concerning the selectivity of fishing gears are also presented.

Automated images processing a tool for better understanding of fish escape behavior

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Underwater video techniques are increasingly used in the field of animal behaviour research. Technological progress regarding video cameras, like frame rate, images quality, battery life, miniaturization, and data storage make these techniques now accessible to a majority of users. However, innovative technologies for observing fish do not lie only on the acquisition system but also on post-processing system. Indeed, so far the videos/photos are mostly qualitative data and are not subject to statistical analysis. Thus, automated images processing software are new tools that can increase the data analysis capabilities of videos/pictures while reducing the time required to analyse these data. The final aim is to use the imaging systems as usable data sources for statistical analysis. In order to understand fish behaviour facing selective devices in trawls, we placed a camera above the devices and recorded fish escapement. Then, we developed an image post-processing program to automatically detect fish. The program was tested on videos taken on bottom-trawls and Danish seine. Thousands of fish escaping the trawls through the selective devices were counted providing important dataset for understanding fish behaviour. The software gave for each fish escaping the trawl an ID number and the time at which it escaped from the trawl.

Initial results from automated video analysis clearly showed that the escapes were not random, but presented a structured escape behaviour.

Field measurement of sinking characteristics of tuna purse-seine of different mesh sizes and its effect of catch performance

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Since the development of China mainland tuna purse-seine fishery in 2001, there is little change in the twine diameter and mesh size of the purse-seine belly. The main dimension of the typical China tuna purse-seine net is 1700 m in length and over 300 m in depth (stretched) , the net is consist of 29 to 30 vertical netting panels (75.6 m in stretched length for each piece) , the belly uses PA 6 × 16–260 mm netting. We carried out the experiments onboard the China tuna purse-seine fishing fleet in Western and Central Pacific Ocean from 23 April 23 to 10 November 2015 to approach the effect of mesh size on the sinking performance of the net by replacing 260 mm mesh size with 300 mm in the belly of the purse-seine. The results clearly indicated that sinking speed increased and abortive haul (catch less than 5 t) rate reduced after the mesh size was enlarged. The average sinking speed of the middle footrope increased from about 0.17 m/s for the original net to 0.19 m/s when 5 panel of netting replaced by 300 mm mesh size netting (increase 11.76%), and further to about 0.21 m/s when 15 panel of netting replaced by 300 mm mesh size netting (increasing 23.53%); the abortive haul rate of the tuna purse-seine reduced from about 0.586 for the original net down to 0.455 (reduced 22.35%), meaning the reduction of abortive haul rate is closely related to the sinking speed of purse-seine.

New method to identify the optimal bar spacing for grids in shrimp trawl fisheries: the case of the deep water shrimp (Pandalus borealis) in the North-East Atlantic

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Grids are often applied as bycatch excluding devices in shrimp trawl fisheries. Retaining shrimps requires the use of trawls with small mesh codends and without any additional selective devices such codends can lead to high bycatch retention levels. To mitigate such problems in several shrimp fisheries sorting grids are installed ahead of the codend. The purpose of such grids is to let the targeted shrimps pass through the grid and enter the codend, while the unintended bycatch fish species are prevented entering the codend. However, due to their abundance preventing the catch of juveniles of certain species is difficult. Selecting the optimal bar spacing for such a sorting grids can be challenging and require many sea trials. The aim is to find the best balance between making the grid sufficiently efficient at letting the biggest most valuable shrimps pass through, while simultaneously being efficient at preventing the juveniles of the bycatch fish species from passing through the grid. Especially in areas where fish juveniles are abundant, this can be a major challenge. One of the key design factors that affects this balance is the bar spacing in the grid. It needs to be sufficiently wide to allow the shrimps passing through the grid and at the same time narrow enough to prevent the majority of the abundant bycatch fish species from entering the codend. In this study we present a new method that allows predicting the effect changing the grid bar spacing up or down based on one set of experimental size selection data for the shrimp target species and the bycatch species by combining this information with simple to carry out laboratory experiments with grid templates and samples of the species investigated. We demonstrate the method on the North-East Atlantic trawl fishery targeting deep-water shrimps (*Pandalus borealis*).

6.7 Fishing Technology to Eliminate Vaquita Bycatch from Fisheries in the Upper Gulf of California

Facilitator:

Jeff Gearhart, NOAA Fisheries (USA)

Mexican efforts to save vaquita marina *Phocoena sinus* from extinction through sustainable fisheries

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Artisanal fishers form the Upper Gulf Biosphere Reserve use drift gillnets to catch blue shrimp (*Litopenaeus styilirostris*), finfish, rays, and sharks. They usually use two sets of 1.2 km long nets (PA Mono 0.37 mm to 0.70 $2^{3/4}$" to $5^{3/4}$" inches mesh size), with incidental catch of vaquita (*Phocoena sinus*). The oceanographic conditions in the area are characterized by strong winds, currents up to 2.8 km/h and semi-diurnal tide heights of 7 m. These conditions, enhance the use of drift gillnets and complicate the operation of alternative gear. Since 2004, different organizations had been carrying out experiments with alternative fishing gear such as shrimp traps and suriperas (modified castnets) without success. However, evaluation of a small trawlnet (50 ft.) has demonstrated to be effective for catching blue and brown shrimp (*Farfantapenaeus californiensis*), in the western coast of the Upper Gulf, at a commercial level. Significant catches were achieved only if gillnets were not fishing at same time, because both fishing gears are incompatible for simultaneous operations. In addition, fishers are reluctant to change and most of them sabotaged all the trials. Environmental factors as high superficial water temperature and productivity affect the abundance and distributions of the resources. Estimates show that during the 2015 season, the availability of shrimp was 50% lower than past seasons. Blue shrimp do not exhibit schooling behaviour, for which is dispersed throughout the region. The efficiency of a small 50 feet trawl require a better understanding of the shrimp behaviour and fisher skills for using the trawl, while the use of 2 driftnets of 1.2 kilometres don't require precision or proficiency. Trawlnet studies by INAPESCA provided the technical support needed to modify current practice requiring the use of trawl gear instead of gillnets, starting in the 2017–2018 season. Currently, there is ban on all finfish and shrimp fisheries (except for curvina --*Cynoscion othonopterus*) for two years (April 2015 to April 2016). INAPESCA with support of International scientific community will develop alternative gear for all resources before the ban ends.

Participation of Civil Society Organizations for developing new gear to substitute gillnets from the Upper Gulf of California

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Vaquita (*Phocoena sinus*) is the most endangered marine mammal of the Planet and the one with the most limited distribution – some 3000km² in Nortwest Mexico (Upper Gulf of California, UGC). The most important threat to the vaquita is bycatch in gillnets used to catch shrimp and finfish in the UGC. The International Commission for Vaquita Recovery (CIRVA) affirms that the only way for saving vaquita is eliminating gillnets from its habitat. Since 2004, the World Wildlife Fund (WWF) works with the Mexican Institute of Fisheries (INAPESCA) for developing alternative shrimp and finfish fishing gear for that end. From 2009 to 2013, both institutions conducted six experimental assessments for a selective trawl system, called RS-INP-MX, demonstrating its effectiveness when gillnets are absent. Since 2013, Mexican fisheries regulations mandate the gradual substitution of shrimp driftnets by the RS-INP-MX. Additionally, in 2012, WWF and INAPESCA tested nine alternative fishing gears for finfish and molluscs to substitute drift gillnets, using a research vessel as experimental platform. Finfish trawl, hook longlines, and fish traps resulted as promising options and additional assessments were continued on board artisanal fishing boats: hook longlines delivered positive revenues, small trawl for finfish revealed operative issues on board artisanal boats and result for fish traps were inconclusive. Non-profit civil organizations for conservation, such as WWF and Pronatura, have been helpful for identifying skilled fishers willing for using alternative fishing gears; undertaking fieldwork and data analysis and meta-analysis; building financial and market capacities among interested fishers and undertaking in-depth experiments for testing specific hypothesis. Vaquita population continues declining at an alarming rate. Experts urge to identify and effectively transfer alternative fishing gear for commercial fisheries at UGC in the next 12 months.

Experiences in the Baltic developing alternative fishing gears to replace gillnet fisheries– Can these experiences be used in the Sea of Cortez?

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Alternative fishing gears for coastal fisheries in Sweden have been developed by the Swedish University of Agriculture Science (SLU) for the past 20 years. The main goal of the development is to decrease the seal fisheries conflict by developing alternative seal-safe fishing gear. We will present some alternatives fishing gear that could be seen as potential fishing gear in the Sea of Cortez as a mitigation method to reduce the bycatch of the Vaquita. A fishing gear that is in commercial use in Sweden, developed by a fisher in collaboration with SLU, is the push-up trap. It has been developed for many species such as migratory species, schooling pelagic species as well as demersal species. These trapnets include a leadernet, a trap consisting of two compartments and a fish-holding chamber. These fishing gear are static gears anchored to the bottom and they can be sensitive to strong currents. However, taking advantage of the strong currents in the Sea of Cortez, trapnet construction floating with the current could be a potential alternative fishing gear in the area. Recent years seine netting for many species such as flatfish, herring, and vendace has been considered as an alternative to gillnet fisheries in the Baltic. To be able to use seine nets in coastal areas on small open boats, a set up with two hydraulic creel winches connected to a hydraulic pump were set on a stainless steel frame was constructed. The construction weighed no more than 100 kg so that it easily can be moved from one boat to another. A small seine with lines up to 440 metres were used together with the winch steel frame construction to catch species such as perch, vendace and white fish. The development is ongoing however the preliminary results show that the new gear has potential. However seine netting requires local and traditional knowledge of fishing grounds. The Swedish bottom seine method could be an alternative environmental and economic viable alternative to gillnets on suitable bottoms in the Sea of Cortez. It is a method developed for small boats, as the pangas used in the area, and could be used for catching species, such as Pacific Sierra, inhabiting Mexican waters. Past years, SLU has focused their gear development on finding alternatives for gillnet fisheries for cod. Cod pots have shown to be a promising alternative. These pots can also be used as multifunctional pots, allowing using the same pots for multiple species. By replacing selection panels or entrances, the same pots can be used for different species during different fishing seasons. Multifunctional pots for lobster and cod have been developed for small-scale fisheries in Sweden. In the Sea of Cortez, pots for fish, such as the goldspotted sand bass and the baqueta grouper, have been tried with promising results. Experiences from Sweden such as multifunctional pots could be valuable in these fisheries.

A bottom–up social process to find fishing gears different from gillnets to reduce vaquita (*Phocoena sinus*) bycatch

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The only legal alternative gear for replacing shrimp gillnets in the upper Gulf of California (UGC) is the light trawl (RS-INP-MX). Though research on this gear has shown positive results for the target species, it has generally not been accepted by fishers. Beginning in 2009, fishers have been required to work under an environmental impact study. One of the mitigation measures required to be implemented was to find socially acceptable and credible alternative fishing gear for the shrimp fishery that would reduce the bycatch of the endangered vaquita porpoise (*Phocoena sinus)* in gillnets. A participatory "bottom–up" social process was conducted for obtaining proposals for alternative fishing gear. A contest was organized, ten prototypes were submitted, and experts gave feedback during a workshop. Based on expert opinion, the most feasible gear were included in a protocol submitted to CONAPESCA, as part of the requirements to obtain a research permit. This process allowed us to involve fishers in proposing solutions to a conservation problem. Special care was given to assure proposals met current fishing regulations and conservation priorities. This approach was also key strategy to obtaining credibility among a small group of fishers and for initiating a natural process for adoption of new fishing gears. Experience has shown that adoption of fishing gears is a process of simple imitation, passed on from fisher to fisher. To date, the fishing gear proposed through this process are the only options available besides those that have already been approved by INAPESCA and supported by WWF.

Initiatives to protect porpoises in Denmark

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The Danish Seas are inhabited by three different populations of harbour porpoises (*Phocoena phocoena*), the North Sea, the Inner Danish waters, and the Baltic Sea population. The first two are in favourable conditions however the Baltic population is critically endangered. In EU, the porpoise populations are protected under the Habitat Directive (HD) and European Council Regulation 812/2004. As Denmark is obliged to fulfil the HD and Regulation 812 several of initiatives have been put forward to monitor and prevent bycatch in commercial fisheries. In Denmark bycatch of marine mammals are monitored by use of CCTV cameras. A portion of the commercial gillnet fleet carried electronic monitoring systems and recorded in all trips. Time and position are logged and all net hauls are recorded. Video footage is afterward analysed and bycatch rates are estimated. Despites the monitoring programs several developments are in progress to avoid porpoise bycatch. (I) Development of new cod pods as an alternative fishing gear to the gillnet fishery. The main focus is to find the most efficient size, shape, and entrance. (II) Pinger trials. New pinger types are tested in the fishery and traditional pingers are investigated in related to effective range and habituation. (III) Gillnet modification. Trials on gillnets modifications are conducted to examine if e.g. low turbot nets have less bycatch compared to regular height nets. Furthermore the Danish AgriFish Agency has established an expert group to support, them as managers, in relation to scientific advice on porpoises and their interactions with fisheries.

6.8 Poster Session

Application of the Kotter Model to the Raised Footrope Trawl

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The Kotter change model represents a possible framework for understanding how change comes about generally. Its application to fisheries has been considered and applied to several case studies. This talk will review the history of the development of the raised footrope trawl, an early example of a successful collaborative gear research program. This gear was implemented as a regulation and was broadly adopted. It continues to be used today. As a successful program, it provides a test case for the applicability and utility of the Kotter model.

Bioeconomics of technological interdependencies between artisanal and industrial fleets of the shrimp fishery in the southern Gulf of California

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The Mexican Pacific shrimp fishery is the most important fishery in México, being the southern Gulf of California one of the most important fishing areas. Two fleets participate in the fishery: an inshore artisanal fleet and an industrial one. The inshore fleet targets juveniles and pre-adults of white shrimp (*Litopenaeus vannamei*), and fishers use wood sticks barriers along the channels (called tapos) to prevent shrimps escaping to offshore ground. Artisanal fishers also use throwing nets (called atarrayas) from land or from canoes (5 m long) some equipped with 15–45 hp engines. The offshore industrial fleet targets pre-adults and adults of white (*Litopenaeus vannamei*), blue (L. *stylirostris*), and brown shrimps (*Farfantepenaeus californiensis*). The industrial fleet is composed of vessels (18–23 m) equipped with two trawling nets with 30–40 days autonomy. The sequential nature of this fishery imposes technological interdependencies between the fleets capturing the same stock at different life stages. The spatial effort distribution of both fleets for the 2014–2015 shrimp fishery season is also reported in this study. To assess the sequential technological externalities between fleets, a multispecies and multifleet age-structured bioeconomic model was developed with M-at-age (natural mortality-at-age) and fleet specific catchability-at-age.

First report of the effect of fish excluding devices in shrimp trawlnets in the fishing fleet of Tux-pan, Veracruz, Mexico

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Fish Excluder Devices (FED), model "fish eye", were installed in trawlnets to evaluate its effect on the volume and composition of the shrimp catch. FED were built forming an oval ring with axis length of 420 and 210 mm. The tests were conducted in Veracruz, Mexico, aboard a shrimper ship with hull steel, 22 metres length with Caterpillar engine of 402 HP; the ship incorporated a twin-net system with float lines of 47 feet each. 12 fishing hauls were carried out, for a total of 46 hours of drag; the swept-area was 8.7 km^2, at 31 and 82 m deep. The catch was classified into six groups of species: shrimp, other crustaceans, finfish, molluscs, elasmobranch, and discards. FED was installed in the internal nets port and starboard, while external nets in both bands worked without DEP. For nets without DEP total catch was 2044 kg, 310 kg fish retained and discarded 1016 kg. For nets with TED, the total catch was 1793 kg, 214 kg fish retained and discard 852. It was observed that there is a positive effect by using FED´s by reducing the total catch, fish retained and discards by 12.3, 16.1 and 30.9% respectively. Out of total fish retained, *Menticirrhus americanus, Cynoscion arenarius, Upeneus parvus* and *Saurida* sp. had a reduction of 73.6, 42.6, 29.3 and 18.1% in capture with the use of FED.

About the reconversion of a trawler to a longliner

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A trawler from the French fishing company Scapêche has recently been reconverted to semi automatic longliner. The 33 m fishing vessel has been reconverted to reduce by catch, fuel consumption and physical impacts on the seabed, usually associated to trawling practices. A first period was dedicated to the training of the crew who was new to this métier. This period was based on the use of benthic longlines. However, the fishing company objective is also to target hake and cutlass fish in deep waters. Thus semi pelagic longlines have been designed, using a simulation tool developed for this project. A sea trial was undertaken by the end of 2015. Measurements using depth sensors were achieved on pelagic and benthic longlines in order to validate simulation results. Sinking velocity, which is important for the bait efficiency especially on deep water, and longline shapes were found in good accordance with the model prediction. We noticed a strong effect of undercurrents on the observed line behaviour, and unfortunately low catch of pelagic fish, presumably due to the choice of working areas which will be improved.

Technological interdependencies of tuna sea ranching and tuna fisheries in the Pacific

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For about 26 years the catch volumes provided by the world's fisheries have remained relatively constant, so it is clear that hardly there will be any significant increase. Given this scenario, one way to increase the value of the catch without increasing the volumes it is through their transformation. A popular alternative is to obtain juveniles from wild populations for their further grown out. This practice is known as capture based aquaculture (CBA). This practice has sometimes been perceived as a negative activity, mainly because there is relatively little information to understand the interactions between this activity and the traditional fisheries. In this vein the "FAO international workshop on technical guidelines for the responsible use of wild fish and fishery resources for capture-based aquaculture production" held in Vietnam in 2007, concludes that in order to take a stand there is a need to assess the biological and economic feasibility of the CBA. To contribute to this matter, this work is intended to evaluate the interdependencies between fisheries and aquaculture through a bioeconomic model of the Bluefin tuna ranching in México. In this presentation, the overall methodological approach as well as the structure of the aquaculture bioeconomic model is shown, the later by itself a useful tool for the optimization of the activity, either to help to plan the production cycles or calculate reference point such as the optimal harvest time.

Effects of new antifouling painting process on fuel consumption for trawlers

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Antifouling paint or bottom paint is a specialized coating applied to the hull of a ship or boat to slow the growth of subaquatic organisms that attach to the hull and can affect a vessel's performance and durability. Hull coatings may have other functions in addition to their antifouling properties, such as acting as a barrier against corrosion on metal hulls that will degrade and weaken the metal, or improving the flow of water past the hull of a fishing vessel or high-performance vessels. Commercial vessels commonly used bottom paints containing tributyltin, which has been banned in the International Convention on the Control of Harmful Antifouling Systems on Ships of the International Maritime Organization due to its serious toxic effects on marine life (such as the collapse of a French shellfish fishery). In modern times, antifouling paints are formulated with copper, organotin compounds, or other biocides—special chemicals which impede growth of barnacles, algae, and marine organisms. Innovative concept of "green" biocide free fouling control coating, featuring unique patented Slime Release paint for displacement steel hulls has been tested on a bottom trawler. Fuel consumption and engine power has been measured before and after the application of the innovative paint and data were compared to monitor the effect on hull resistance. Fuel consumption reduction as well as lower engine power for same speed has been noticed monitoring the vessel for several weeks after the application. Several hull inspections confirmed that no subaquatic organisms persisted even after few months.

Discards mitigation in the trawl Nephrops fishery of the Bay of Biscay: innovations, improvements and challenges

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The trawl *Nephrops* fishery of the Bay of Biscay accounts for one fourth of the total fleet of the French Atlantic area. Trawls used in this mixed fishery are designed to catch *Nephrops*, but because of the wide diversity of species morphology and behaviour present on the fishing grounds, they also generate high catch rates of crustaceans and fish below minimum landing size. In the meantime, the new Common Fisheries Policy (CFP) decrees a discard ban for all species under quota. This new regulation promoted the development of a variety of trawl selective devices aiming at reducing discards without affecting landings. The challenge lies in working out device combinations that are suitable for both *Nephrops* and fish selectivity. In this purpose, several devices were tested on board commercial fishing vessels (twin trawls), e.g. a 90 mm square mesh panel in the tapered section, 55 mm T90 net inserted either in the codend or in the extension piece, or a reduced number of circumferential meshes in the extension piece. GLMM were fitted to proportions of individuals retained at length for each device and main species. The results show significant reduction of the discards, sometimes together with reduction of landings. However, escapement of undersized individuals was never total, what led to a remaining discards fraction, especially for *Nephrops*. These experiments will provide the fishing industry with a "toolbox" of selective devices suitable to the discards issues.

HESPAN, An alternative approach for species selection in Nephrops fisheries

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Nephrops (*Nephrops norvegicus*) is a valuable decapod species, exploited in NE Atlantic by demersal trawl fleets. High bycatch rates are usually associated to these fisheries due to the small mesh codends used to catch the target species. Devices such as square mesh panels and grids have been developed and in some cases implemented to supplement codend selectivity, but the low success often achieved, indicates that new perspectives for alternative solutions are required. HESPAN is a new concept for selection device specially developed for *Nephrops* fisheries. The new concept consists of a long square mesh panel inserted obliquely in the extension of the trawl. The oblique panel is mounted with a smooth bottom–up angle, intended to guide fish species to an upper codend, while sieving *Nephrops* to a lower codend regardless of individual size. HESPAN has been developed and tested in Skagerrak Sea during September 2015. The structural model applied in data analysis estimated more than

85% of *Nephrops* efficiently contacted HESPAN, but the sieving to the lower codend was unexpectedly dependent on *Nephrops* length size. Underwater video recordings collected during the sea trials showed *Nephrops* hitting and rolling over the panel, but also active interactions such as attempts to burying in the square meshes or holding the twines with the claws. We hypothesize that the length dependent probability of catching *Nephrops* in the lower codend might not be related to mechanical size selection, but to active interactions of *Nephrops* with the HESPAN.

The effect of reducing circle hook tensile strength on catch rates in the Gulf of México yellowfin tuna pelagic longline fishery

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The bycatch mortality of spawning bluefin tuna (*Thunnus thynnus*) associated with the yellowfin tuna (*Thunnus albacares*) pelagic longline fishery in the Gulf of México has become a management concern because of the potential overfished status of western bluefin tuna and because dead discards must be accounted for within the limited US quota. Research was conducted by the Harvesting Systems Unit of NOAA Fisheries, Southeast Fisheries Science Center, Mississippi Laboratories to evaluate a new 16/0 "weak" circle hook designed to reduce the bycatch of bluefin tuna in the fishery. Eight commercial vessels completed 414 pelagic longline sets, during which experimental hooks and standard 16/0 circle hooks were alternated, resulting in a total of 245 880 hooks set. A total of 134 bluefin were caught during the experiment, of which 47 were caught on the experimental hook (46% reduction). The difference in bluefin catch was statistically significant. Vessels landed a total of 2561 yellowfin tuna. The catch rate for yellowfin tuna did not differ significantly by hook type.

An optimized pulse trawl design for a selective Crangon fishery

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Current technical modifications aiming for bycatch reduction in the North Sea Crangon fishery, like sieve nets, focus on catch separation or filtering after species have entered the trawl. Sieve nets are satisfactory effective in avoiding the bycatch of relatively large individuals of all species, but less so at reducing 0-group plaice and sole. Because of this drawback alternative measures are recommended. The fundamental idea behind the pulse fishing technique for shrimp is to reduce or remove the relatively heavy bobbin rope and use electrical pulsation as a stimulation alternative. The use of a specific electric field close to the seabed induces a startle response in shrimp and leaves other organisms unaffected. Herein lays the selective fishing potential of this alternative technique. Preservation of commercial catch rates and sufficient reduction of bycatch and seabed contact are the decisive criteria in the evaluation of the different pulse gear designs. Intensive, year-round testing of an optimized electrotrawl on a commercial shrimp cutter on the Dutch Wadden Sea, revealed important results. Direct catch comparison with a standard shrimp trawl indicated that at least as much shrimp can be caught with this specific electrotrawl design. On top of that, an average bycatch reduction of 58% in volume is a major step forward in dealing with the discarding practices in the brown shrimp fishery. Additionally a 65% reduction in seabed contact is a radical change in the environmental impact issue associated with this coastal fishery.

Analysis of bycatch with economic value retained on board, and discards without commercial value in the shrimp trawl fishery of the Gulf of Mexico during 2014

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In 2014 from April to September capture system shrimper twin trawling in the Gulf of Mexico on 15 fishing trips and 632 hauls production of 200 694 kg analysed. The capture qualified and quantified into six groups: shrimp, other crustaceans with commercial value retained on board, retained finfish, molluscs retained, elasmobranchs, and discards. The shrimp group represented 19.6% of the total catch; the bycatch was formed by groups of other crustaceans, fish, and molluscs which represented 15.1%; discards represented 61%. The FACSVD consists of 68.8% fish, 14.14% garbage, 10.77% of crustaceans, molluscs 2.93% and 3.35% algae, echinoderms, poríferos, cnidarians and tunicates. In total discarding 69 families and 131 species were identified. In 53 families with 108 fish species were *Syacium major* sp. 15.52%, *Prionotus* sp. 9.60%, 9.31% *Upeneus parvus*, *Synodus foetens* 6.61%, 5.45% *leucosteus Calamus*. Crustaceans 12 families with 20 species, the main *Squilla* sp. 30.3%, 13.8% Chesapeake Blue Crab, *Sicyonia* sp. 13.1% 8.4% *spinicarpus Portunus, Portunus spinimanus* 6.9%. In molluscs, 4 families with 3 species, *Loliolopsis diomedeae* 59.1%, *Octopus* spp. 0.1%, the remaining 40% are clams and snails. This first description of FACCVR and FACSVD in shrimp trawl system can be a benchmark for assessing technological modifications to the system of traditional fisheries, such as incorporating fish excluder devices and Double luff in trawls.

Improving discard survival in flatfish trawling 2014–2015

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In the light of the EU landing obligation, the chances of survival were studied of sole, plaice and dab in the Dutch demersal fisheries. As part of a large discard survival project it was investigated whether adjustments in the processing line on board of the participating vessels can lead to higher discard survival of sole, plaice, and dab. Five experimental trips were done with one adjusted deck hopper to be compared to a conventional one, for which one vessel was sampled once and the other vessels were both sampled twice. Each vessel had a unique, new deck hopper installed on-board. Each hopper was developed by a particular company; however, the designs were based on a shared principle. The new design allowed fishers to empty the nets in a hopper with ample seawater, and air and/or seawater (and thus oxygen) supply. It was studied whether these adjustments would lead to higher overall discard survival rates. Based on these five trips, it seems that this is indeed the case. However, the observed discard survival in the adjusted hoppers varied widely. One of the trips was done in bad weather conditions and on the other hand the survival monitoring in the laboratory of two trips was aborted due to a Vibrio-infection. Definite conclusions about potential higher discard survival estimates can therefore not being drawn yet. The new deck hoppers should be (self) sampled for more trips, under various circumstances, to determine actual increase of discard survival rates.

High precision remote SBT (Small Bathy Thermometer)

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The newly developed Remote SBT is a bathy thermometer capable of ultrasonic communication. It can measure the temperature and depth, and then transmit them to a receiver on ship. The conventional SBTs can also measure and record these data but none of them can transmit them to a receiver. The remote SBT cannot only transmit the data but also can store them into the inside memory. The special feature of ultrasonic communication used in this remote SBT is the pulse interval modulation that creates three pulses: the basic, depth and temperature pulses. Each pulse interval is proportional to depth and temperature values. These three pulses consist of modulation signals made of 5th order Gold code sequences and the frequency used is 62.5 kHz. The receiving signal is processed by a correlation device custom LSI developed by FUSION INC. Ten of remote SBTs can be processed simultaneously. We introduce the Remote SBT device and the obtained data compared to conventional CTD in actual seawater.

Development of small fishing gear monitoring system using an acoustic telemetry

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Many acoustic instruments have been used in marine fisheries for efficient fisheries. Especially, acoustic systems for monitoring fishing gear performance can improve operational efficiency and contribute to low cost and low impact fisheries. In this study, the system for real-time monitoring the depth of small fishing gear was developed using acoustic telemetry to improve the efficiency of fishing operations. The system consisted of an acoustic transmitter (pinger), an omnidirectional hydrophone with a depressor, and a receiver. Using a pinger equipped with a depth sensor, a fisher can confirm whether the fishing gear is at the intended depth. The system was evaluating the effectiveness by implement in hooks and lines fishing. The results showed that the system could monitor the depth of the fishing gear continuously in real time. The accuracy of measured depth was 0.4 m and was constant even if the pinger was moving. In the experiment, the system could successfully monitor the pinger depth every several second. Because fishers are possible to adjust the depth accurately and easily, the system can prevent wasted operation leading to excessive use of fuel. The implementation experiments revealed some issues with the system, such as the effect of signal reflections or the installation method of the hydrophone.

7 Topic Group: Technical Innovation in Spreading Trawls

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

Summary of Findings

The purpose of this topic group was to provide a synthesis of recent technological advancements in the spreading of mobile trawls. Moving beyond basic doors and beams, this report documents 17 new and leading innovations. In many cases, scientific literature is still absent on their engineering and catching performance. This represents a snapshot in time. It is a picture of innovative technology under development. Contributions were collected over a three-year period (2014–2016) from 29 participants from 17 countries. Looking forward, we are encouraged by the rate of R&D in this field. We see examples of academia, government, and industry all working on innovative concepts. The development and commercialization of novel products by door manufacturers is a particularly encouraging sign.

7.1 General Introduction

The ecological impacts of fishing activities on ecosystem structure and function have been expressed at the local, national, and international scale. To an increasing extent, the global seafood industry is facing public pressure to amend its fishing practices in an effort to reduce bycatch, carbon footprint, and seabed impacts.

Evidences that fishing gears can alter substratum shape, resuspend sediment, injure benthic organisms, reduce habitat complexity, and reduce biodiversity are now well documented in the scientific literature (e.g. reviews by Jones, 1992; Kaiser *et al.,* 2003; Lucchetti and Sala, 2012). Many NGO's have successfully leveraged these scientific developments to pressure seafood brokers and retailers to source and sell only sustainably caught seafood. And in response to this pressure, a significant number of fishing gear modifications have been developed over the last couple decades to mitigate ecological impacts (reviews by Valdemarsen and Suuronen, 2003; Valdemarsen *et al.,* 2007; He and Winger, 2010; Sala *et al.,* 2014).

In the case of mobile trawls, attention over the last couple of decades has focused on the development of improved methods of spreading the mouth of the trawl. Moving beyond basic doors and beams, new research efforts have been focused on off-bottom doors, manoeuvrable or controllable doors, kites, novel footgears, and hydrodynamic beam concepts.

The purpose of this topic group was to provide a synthesis of these recent technological advancements toward the goal of stimulating innovation and creating opportunities for technology transfer.

7.2 Terms of Reference

A group of experts met three times:

1) 2014 at the FTFB meeting in New Bedford, MA, USA
2) 2015 at the FTFB meeting in Lisbon, Portugal
3) 2016 at the FTFB meeting in Merida, Mexico

The goal was to document and evaluate recent technological advancements in spreading technology for mobile trawls. The terms of reference were:

1) Describe and summarize new and innovative technological advancements under development (or recently developed) for spreading mobile trawls.
2) Review technical challenges and obstacles for uptake by industry.
3) Identify new applications for these technologies and opportunities for technology transfer.

This report represents the final deliverable for this topic group.

7.3 List of Participants

The following names include participants during the year 2014–2016. Some attended all three years while other may have attended one or two years.

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7.4 Summary of Recent Advancements

Manoeuvrable Trawl Doors – Norway

Manoeuvrable trawl doors are currently under development by government and industry scientists in Norway. The project is a partnership between the CRISP project led by IMR and an industry partner - Egersund Trawls. The wireless technology allows the vessel to communicate with the doors using a 2-way acoustic modem. Wireless acoustic commands are given to open and close panels in the doors (Figure 7.4.1). This change in surface area of the door affects its spreading power. Opening panels in the top or bottom affects the heal of the door, which changes lift. Changing surface area was found to be a less energy intensive approach than changing the angle of attack of the door. Batteries can last 3 days. Two potential applications are envisioned: a) vessels fishing semi-pelagically on slopes or in side-currents, and b) vessels that target two species of fish in the same trip. If they have different trawls, they would normally need to sail with two types of doors. Now they can fish both trawls with one set of doors because these manoeuvrable doors can change their spreading power.

Challenges are primarily attributed to the acoustic modem at this time. While results to date have been very encouraging, the acoustic communication between the vessel and doors is currently too unreliable to permit the technology to be commercialized. Partners on the project are currently investigating opportunities for further development (see further details in CRISP, 2015).

Controllable Trawl Doors – Iceland

Controllable trawl doors for pelagic fishing are currently under development by Polar Trawl Doors in Iceland (Figure 7.4.2). Starting in 2013, the company has invested significant R&D efforts over the last few years, including both flume tank and at-sea trials. The doors consist of several adjustable wings. When the wings open, more water passes through the door, reducing its spreading power. Depending on which wings are opened, the trawl can be steered horizontally and vertically. Two-way wireless communication between the vessel and doors is conducted using transponders developed by Notus Electronics Ltd. from Canada.

Latest sea trials were conducted as recent as spring 2016. The product is branded "Poseidon". The product is expected to be commercially available in the near future. No scientific literature available. See company website for more information (www.polardoors.com).

Xstream Trawl Doors

Thyborøn Trawl Doors recently released Xstream trawl doors for bottom, semi-pelagic, and pelagic trawling activities (Viking, El Casador, and Apollo). The patented "free-flow slot" technology claims to significantly reduce turbulence behind the trawl door, thereby reducing drag and making the doors more stable and easier to tow (Figure 7.4.3). No scientific literature available. See company website for more information (www.thyboron-trawldoor.dk).

Flipper Trawl Doors

In 2014, Thyborøn Trawl Doors released a series of patented Flipper trawl doors. The technical advancement has been applied to the Type 15VF pelagic trawl door to produce Type 20 VF Flipper. It is also been applied to the Type 14 VF semi-pelagic trawl door to produce Type 21 Flipper. Adjustable foils within the door, two in the upper part and two in the lower part, can be manually open and closed to reduce or increase spreading power and towing resistance (Figure 7.4.4). The company's marketing material says "now you can have two sizes of doors in one". This provides flexibility to the vessel when targeting multiple species with different trawls. No scientific literature available. See company website for more information (www.thyboron-trawldoor.dk).

Ekkó Trawl Doors

This new trawl door just completed its initial debut sea trials in April 2016. Developed by inventor Smári Jósafatsson in Iceland, this door is unique in that all connection points are on the front of the trawl door (Figure 7.4.5). No scientific literature, marketing material, or social media available at this time.

Batwing Trawl Doors

Developed for tropical penaeid bottom trawls, this innovative trawl door is constructed of a flexible kite rigged an angle of attack to the water flow, but with a benthic ski that travels in the direction of tow (Figure 7.4.6). The result is significantly less contact area with the seabed, resulting in less disturbance of the benthos (Sterling and Eayrs, 2010; McHugh *et al.*, 2015).

Jumper Door

This innovative trawl door concept was initiated under the DEGREE project (van Marlen, 2010). It was a partnership of Ifremer and the industry partner Morgère. The shape is based on the Suberkrub door. Using the addition of a small shoe, the door makes limited contact with the seabed (Figure 7.4.7). This reduces contact area with the seabed as well as reduces sediment suspension. The door is designed to roll inward and produce lift when touching the seabed. Numerical modelling, flume tank evaluations, and sea trials were conducted over a period of several years to refine the technology. Back-strop arrangement was shown to be important in adjusting the centre of gravity and behaviour of the door. Field observations have demonstrated 10 times lower sediment resuspension compared to traditional trawl doors. The technology is now commercialized. It is available for purchase through the company Morgère (http://www.morgere.com).

Semi-Pelagic Trawl Doors

Developed more than a decade ago, this technique of fishing became possible with the advent of (ruggedized) hi-aspect trawl doors that were capable of spreading a bottom trawl without the need for shearing forces with the seabed. It is particularly beneficial in fisheries that do not require sand clouds for herding target species. Feasibility studies have been conducted in Canada (DeLouche and Legge, 2004), USA (He *et al.*, 2006), Spain (Folch *et al.*, 2007; Prat *et al.*, 2008), Italy (Sala *et al.*, 2009; Mellibovsky *et al.*, 2015) and Norway (Grimaldo *et al.*, 2015). The technique is typically characterized by a lifting the doors off-bottom while keeping the trawlnet on-bottom (see description by He and Winger, 2010). Several trawl door companies have commercialized such products, including NETsystems, Morgère, Thyborøn Trawl Doors, Injector, Grilli, Mori, and Polar Doors.

SumWing and PulseWing

The Dutch company HFK Engineering developed the so-called 'SumWing' as a replacement of the common design of a heavy cylindrical beam with two trawl shoes in the flatfish beam trawl fishery (Figure 7.4.8). The conventional beams have been replaced in most of the fleet by SumWings, with less bottom impact and a fuel reduction of 10–15%. Adjusted designs with more height and abrasion-resistant materials were made for the rougher fishing grounds of the southern North Sea. A variation with electrical stimulation was developed later by the same company and got the name 'PulseWing' (http://www.sumwing.nl) (van Marlen, 2012).

HydroRig I & II

A new spreading technology was tested in The Netherlands for beam trawlers targeting plaice. The design was originally based on the scallop dredge with spherical cups presented by Cliff Goudey in the 2006 Boston Fishing Technology Symposium, and got the name HydroRig I. Various designs were tested in full-scale, and in a towing tank. An innovative beam (termed HydroRig II) wider than the traditional beam (15 m instead of 12, which is the legal limit) with two wheels replacing the conventional trawl shoes was tested in a follow-up project (Figure 7.4.9). The beam includes an upside-down wing, which produces a pressure drop for scooping up fish in the trawl path. Total weight reduction is about 5.6 tonnes. The gear is used for catching plaice and the fishers reported similar catches as conventional beam trawlers fishing in the area (van Marlen, 2012).

Demersal Seine Rope Dynamics

Scientists at SINTEF and UiT have been investigating the effect of seine rope layout pattern and haul-back procedure on fishing area in demersal seining. The project *"Danish seine: Computer based Development and Operation"* was initiated in 2013 with the main objective to develop software tools that would ease transition to the Danish/Demersal seine fishing method. This included tools to simulate the behaviour of the fishing gear during fishing with different riggings and operational procedures. Numerical models were developed and validated using physical models in a flume tank (Figure 7.4.10). Results showed that the effective fishing area (EFA) can vary between 0.70 and 1.23 km^2, depending on lay-out. The square (rectangular) and diamond (trapezoid) shape showed the highest value. For more information, see Madsen *et al.* (2015ab).

New software tools to simulate demersal seine fishing have been developed, including: *SeineSolver*: a new software tool to estimate the physical behaviour of the seine gear during fishing, *SeineFish*: a new software tool to simulate catch performance of a demersal seine fishing process, and *SeineViewer*: a new software tool that allowe playback and visualization of the physical behaviour of the seine gear during a simulated fishing process.

Knot Orientation

Broadhurst *et al.* (2016) recently demonstrated the effect of knot orientation on the hydrodynamic performance of a penaeid bottom trawls. The authors found that when the top and bottom belly panels were oriented with a negative angle of attack, the trawl produced greater wing-end spread. Although small (2% increase), the effect was statistically detectable. See Broadhurst *et al.* (2016) for further details.

Kites/Depressors

Kites have been attached to bottom and midwater trawls for several decades in effort to increase hydrodynamic lift. These include attempts to increase headline height, depress the fishing line, and provide horizontal spread (see Figure 7.4.11 for examples). While a complete review is not possible here, the following are some examples:

1) Simple fabric panels (e.g. Goudey, 1999, 2003),
2) Tapered fabric devices (e.g. Ishizaki *et al.*, 2005; Aeroplane by Morgère),
3) Fabric parafoils (e.g. Goudey, 1999, 2003; Kumazawa *et al.*, 2010),
4) Fabric aerofoils (e.g. Ishizaki and Fuwa, 1999),
5) Fabric concepts for spreading trawl extension pieces, codends, and codend covers (e.g. Goudey, 1999, 2003; Madsen *et al.*, 2001; He, 2008),
6) Rigid concepts for creating additional headline lift, including the Exocet kite (ICES, 2012) and Vónin Flyer™.

Self-Spreading Plate Gear

An innovative footgear concept that utilizes a series of plates rather than traditional rock-hopper discs. The plates can be rigged to provide a lifting or depressing function (Figure 7.4.12). Flume tank and field trials have demonstrated the novel footgear also provides an outward spreading function. For more information, see Hansen and Valdemarsen (2006); Valdemarsen *et al.* (2007).

Self-Spreading Semi-Circle Plate Gear

The self-spreading semi-circle plate gear (SCPG) is a further development of the self-spreading plate gear (see above). This new footgear is hydrodynamically more stable and operationally simpler than the self-spreading plate gear. The curved-shaped plates give the footgear a lower angle of attack respect to obstacles (stones), allowing the gear to jump over them very easily (Figure 7.4.13). When directly compared to the traditional rock-hopper footgear, the SCPG gave approx. 7% more spreading and captured between 30 to 50% more cod and haddock (Larsen *et al.*, 2015).

Wing Trawling System

In 2014, an innovative system was developed by a small company in Alabama, USA. Called "*wing trawling*", this system was designed to reduce fuel costs, reduce bycatch of finfish, and eliminate trawl doors (otter-boards) from the traditional methods of harvesting tropical shrimp in Federal US Waters (outside 9 NM). The system is characterized by a large metal aerofoil that holds the mouth of the trawl open, rather than traditional trawl doors (Figure 7.4.14). Removing the doors is claimed to reduce seabed impacts, fuel consumption, and bycatch. Several vessels are reported to be using the system. The National Marine Fisheries Service (NMFS) and the University of New Orleans have initiated a study to (independently) evaluate the catching performance. Results are expected late 2016. Visit the company's Facebook page for more information: https://www.facebook.com/wingtrawlingsystem/

Use of High Strength Netting Material

New trawl designs include the use of a new high strength material and the use of larger meshes in net areas where no negative effect on the catching power is foreseen. It is essential that the new designs combine the features of large headline height and good contact between the footrope and the seabed, with a low towing resistance. A recent study has been conducted in Italy (Sala *et al.*, 2007), where a typical commercial trawl, was selected as a basis for the development of new designs. To reduce the netting area of the experimental trawl, a high strength Dyneema fibre was tested. The intention was to reduce the mesh twine diameter while keeping the netting strength constant. Dyneema was used in the wing section of the experimental trawl. The results from the sea trials show that it is possible to design trawls with up to 30% less fuel consumption and up to 40% more headline height, when larger mesh sizes, new high strength materials and reshaped wings are introduced. However, further product development is necessary before such material could be commercially used in the commercial fisheries.

7.5 Discussion and Recommendations

Participants of the topic group shared their knowledge and expertise related to recent and ongoing R&D developments. The feeling among the group was that technological advancement had occurred in the field and that this review was helpful and productive.

Technical challenges in this field continue to be largely related to generating lift in novel and creative ways. Lift is created when a positive pressure area builds on the face of an object and a negative pressure builds on the backside of the object (Bernoulli). Lift is also created as the accelerated water passing over the back of an object exits from the trailing edge. The reaction of the exiting water creates lift (Newton). But how do we increase lift?

$$L = C_L \times \rho \times \frac{V^2}{2} \times A$$

Based on the above equation, lift (L) can be increased by improving the engineering and orientation of an object (e.g. door or kite) to produce a higher coefficient of lift (C_L), increasing towing speed (V), or increasing area (A) of the object.

But lift never comes free. There is always drag. This is an unavoidable outcome of towing objects through the water.

$$D = C_D \times \rho \times \frac{V^2}{2} \times A$$

Based on the above equation, drag (D) can be decreased by improving the engineering and orientation of the object to produce a lower coefficient of drag (C_D), decreasing towing speed (V), or decreasing area (A) of the object. Large reductions can be realized by reducing towing speed, but this will reduce lift. Reducing object area will also reduce drag, but likewise reduces lift. So it is the relationship between the two that is important.

In many towed applications the towing speed (V) cannot easily be adjusted in any dramatic way as it has been carefully matched to the target species capture behaviour (Winger *et al.*, 2010). For this reason, most engineering activities have been focused on the development of innovative concepts that maximize C_L while minimizing C_D for an object at a given towing speed. These values can be numerically derived using computational fluid dynamics (CFD) software, physically derived using flume tank observations, and empirically measured at sea (e.g. Sala *et al.*, 2009; Mellibovsky *et al.*, 2015). One of the challenges identified during our group discussions was the fact that CFD software (e.g. Fluent, OpenFoan, SolidWorks) sometimes produces results that disagree (B. Vincent, Ifremer). No immediate solution was identified, only that multiple techniques should be used as complimentary methods in an effort to make best predictions.

The feasibility and potential advantages of wind tunnel testing of otter board designs have been assessed in the recent EU-BENTHIS project. Traditional flume tank tests can incur in high operational costs and present some limitations in flexibility and accuracy. Modern flume tanks, despite more flexible and accurate, are still expensive to operate or hire. Wind tunnel facilities are widespread, with a potential for low budget tests, and allow for an accurate control of velocity, angle of attack and sideslip as well as precise measurement of forces and moments in all three axes (see Figure 7.5.1). A complete description of otter board hydrodynamics is paramount to optimizing design and rigging and for the design of active control strategies that allow for stable trawling at a target speed and depth. Mellibovsky *et al.* (2015) describe in detail the methodology of wind tunnel tests applied to general otter board designs, exemplify it with a commercial pelagic otter board and provide a comparison with existing flume tank results for the same design.

Looking forward, we are encouraged by the rate of R&D in this field. We see examples of academia, government, and industry all working on innovative concepts. The development and commercialization of novel products by door manufacturers is a particularly encouraging sign.

But are there barriers to uptake by industry? As academics and government scientists, we recognize that we may be biased in our interpretation of how decision-making is done by fishers (see Eayrs, 2016, for detailed analysis and discussion). Thankfully, this particular research discipline (i.e. the spreading of trawls) does not have close fishery management implications. By and large, fishery authorities do not regulate the type and number of floats, presence of kites, or size and style of doors, etc. So innovation can (to some degree) unfold and occur unfettered. Put another way, these types of changes are generally categorized as “evolutionary-core” in nature because of their low technical risk and positive influence (disturbance) on fish landings and profitability (Figure 1 in Eayrs *et al.,* 2015). But this does not entirely eliminate barriers. Some fishers simply prefer the *status quo*, as was the case with semi-pelagic trawl doors in the Gulf Maine (Eayrs *et al.,* 2015). With pressure from economy (high fuel costs) changes may indeed be swift and profound, as shown by the example of the Dutch beam trawl sector, where almost all cylindrical beams have vanished in a few years’ time. Thankfully, none of the participating members in our group could point to concrete examples of useful and/or profitable innovation that failed to be adopted by industry. For this reason, we remain encouraged. We recommend continued innovation and R&D occur in this field.

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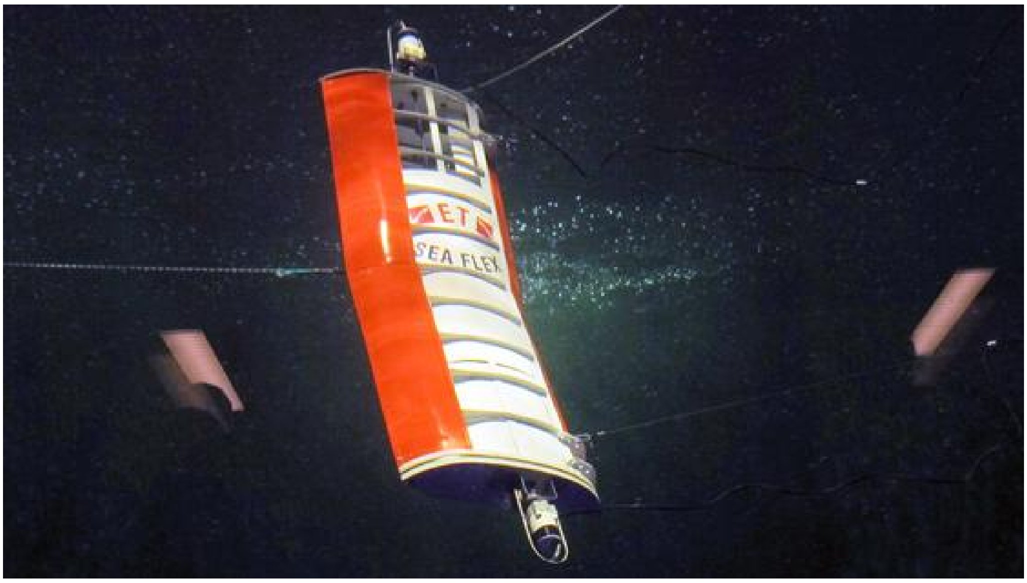

Figure 7.4.1. Model of a manoeuvrable trawl door manufactured by Egersund Trawls. Panels in the door open and close, changing the spreading and lifting power of the door (*image courtesy of Jon Willy Valdemarsen - IMR*).

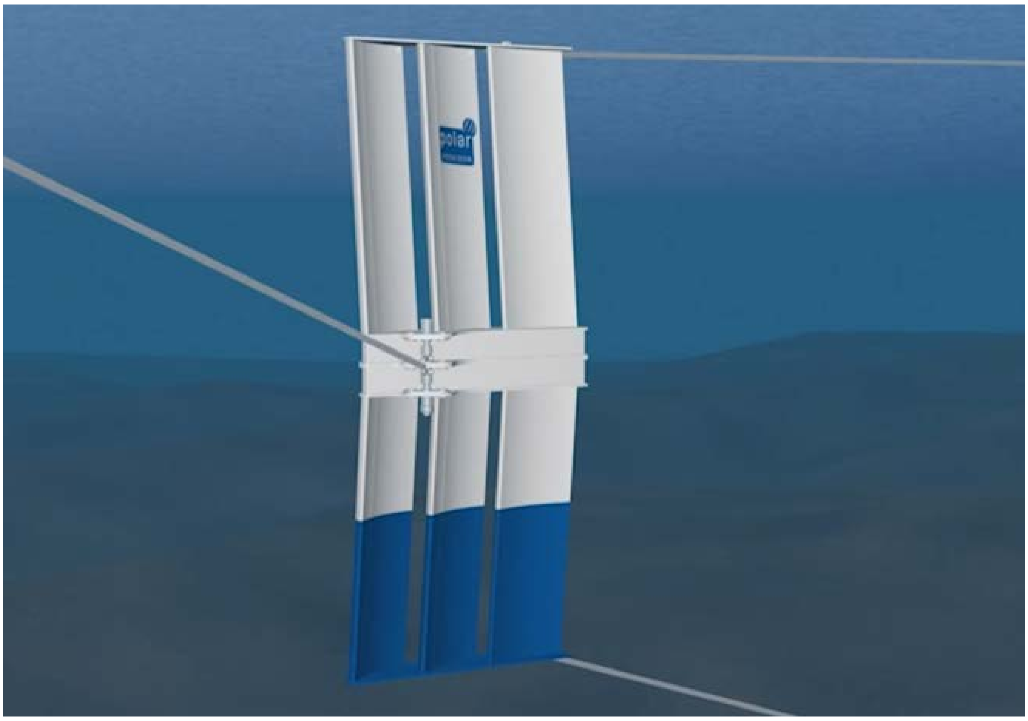

Figure 7.4.2. Controllable trawl doors under development by Polar Doors in Iceland (*image from YouTube*).

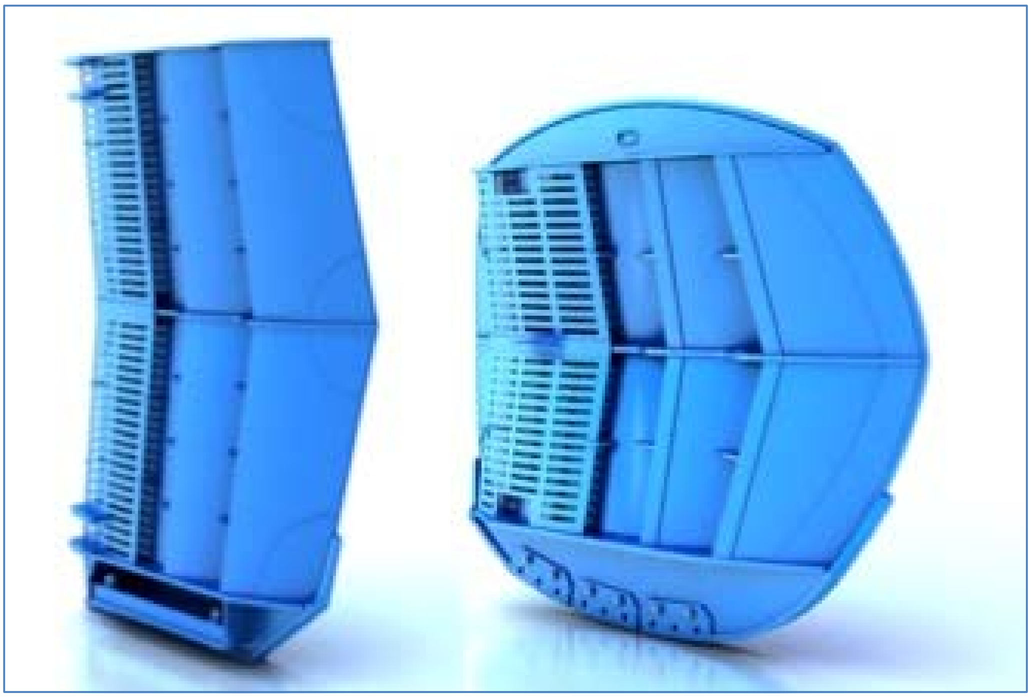

Figure 7.4.3. Xstream technology from Thyborøn trawl doors (*images from company website*).

Figure 7.4.4. Flipper technology from Thyborøn trawl doors. Shown here are the Type 20 VF Flipper and Type 21 VF Flipper for pelagic and semi-pelagic trawling, respectively (*images from company website*).

Figure 7.4.5. Ekkó trawl door developed by inventor Smári Jósafatsson in Iceland.

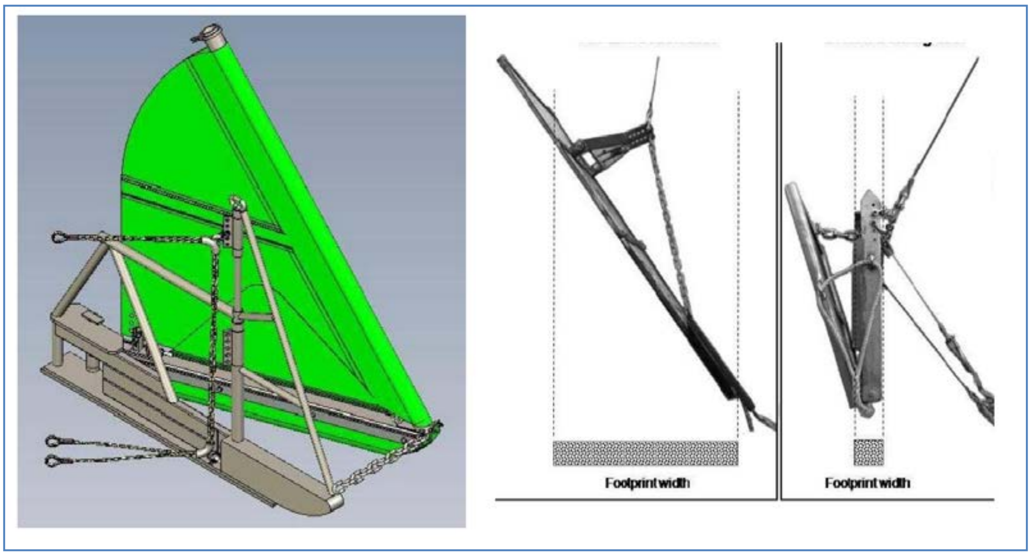

Figure 7.4.6. Batwing trawl door developed by Sterling Trawl Gear Services.

Figure 7.4.7. Full-scale prototype of the Jumper Door developed by Morgère and Ifremer (*image courtesy of Benoit Vincent - Ifremer*).

Figure 7.4.8. Left: SumWing beam, right: Pulse Wing (*Source: HFK-Engineering, H. Klein Woolthuis*).

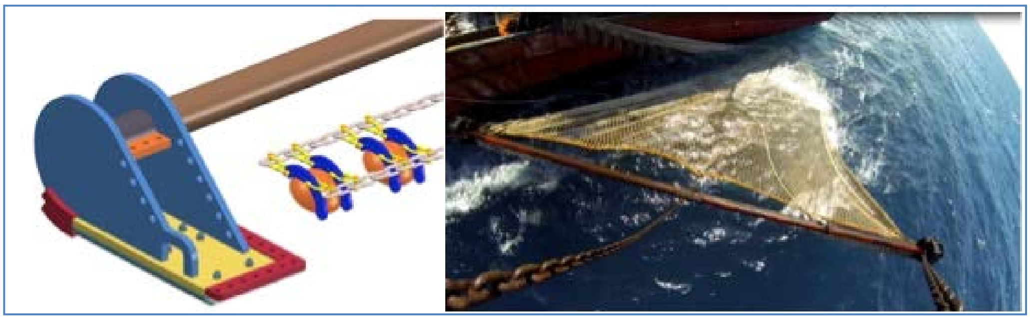

Figure 7.4.9. Left: HydroRig I (Source: VCU-TCD of Urk Netherlands, Roelof van Urk), right: HydroRig II aboard a Dutch beam trawler (image courtesy of Geertruida Ltd. of Urk Netherlands).

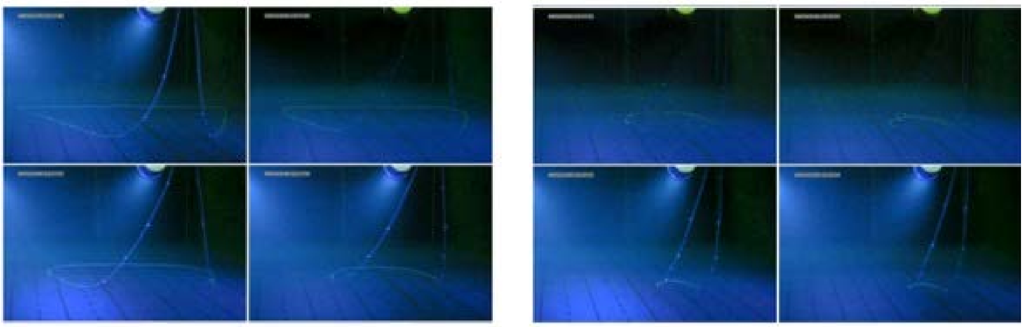

Figure 7.4.10. Flume tank evaluations of different demersal seine configurations, including initial rope layout and haul back procedure (*image courtesy of Bent Herrmann - SINTEF*).

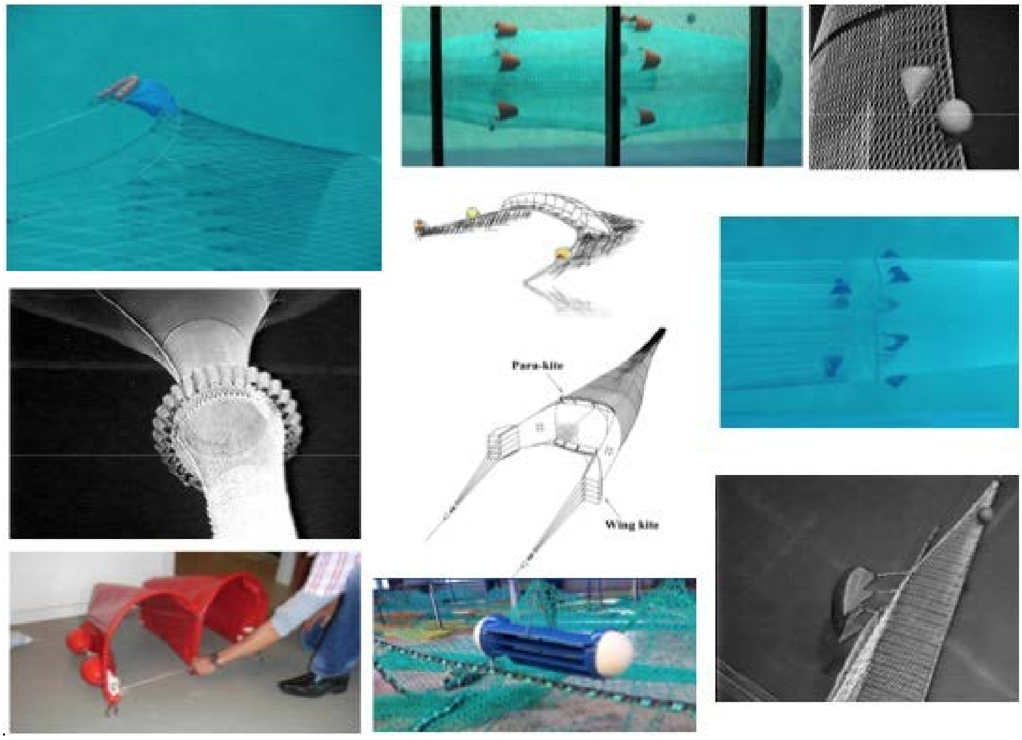

Figure 7.4.11. Various examples of model and full-scale kites, including simple panels, triangular kites, ribbon/ring foils, aerofoils, parafoils, and rigid concepts.

Figure 7.4.12. Self-spreading plat gear developed by Hansen and Valdemarsen (2006).

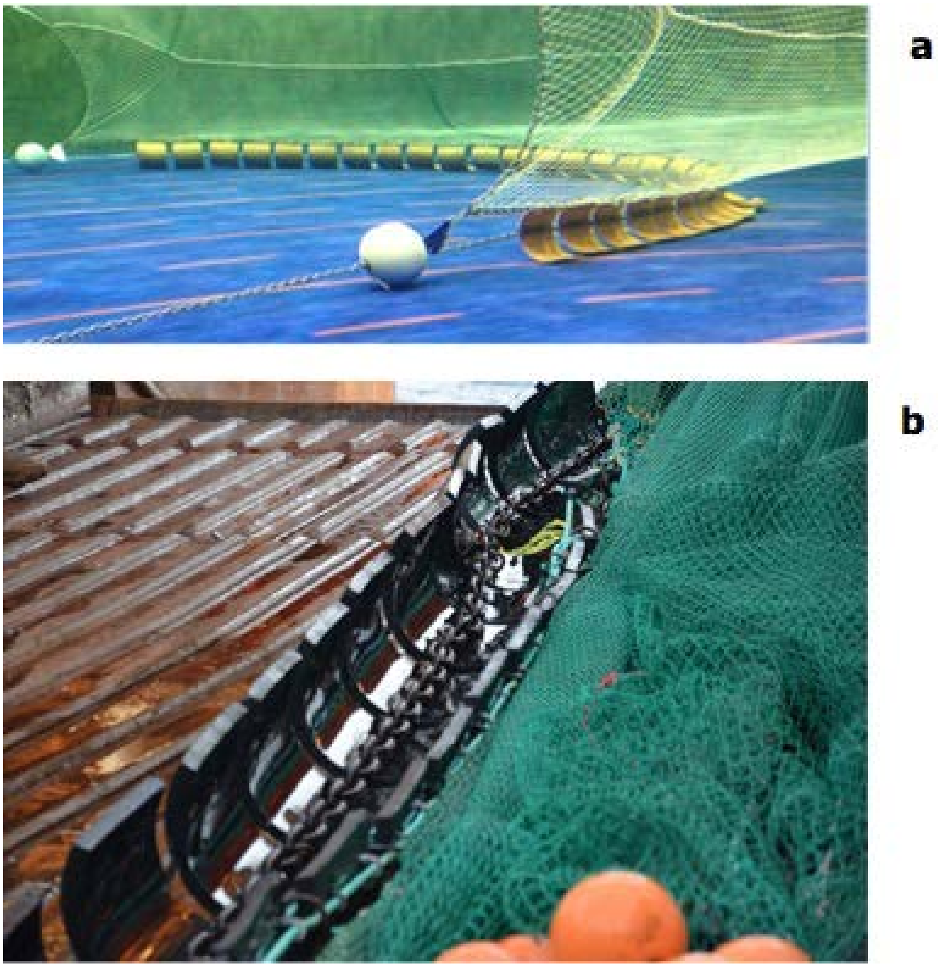

Figure 7.4.13. Self-spreading semi-circle plate gear developed by SINTEF: a) image of a model scale in the flume tank, b) image of a full-scale footgear at-sea (*images courtesy of Eduardo Grimaldo - SINTEF*).

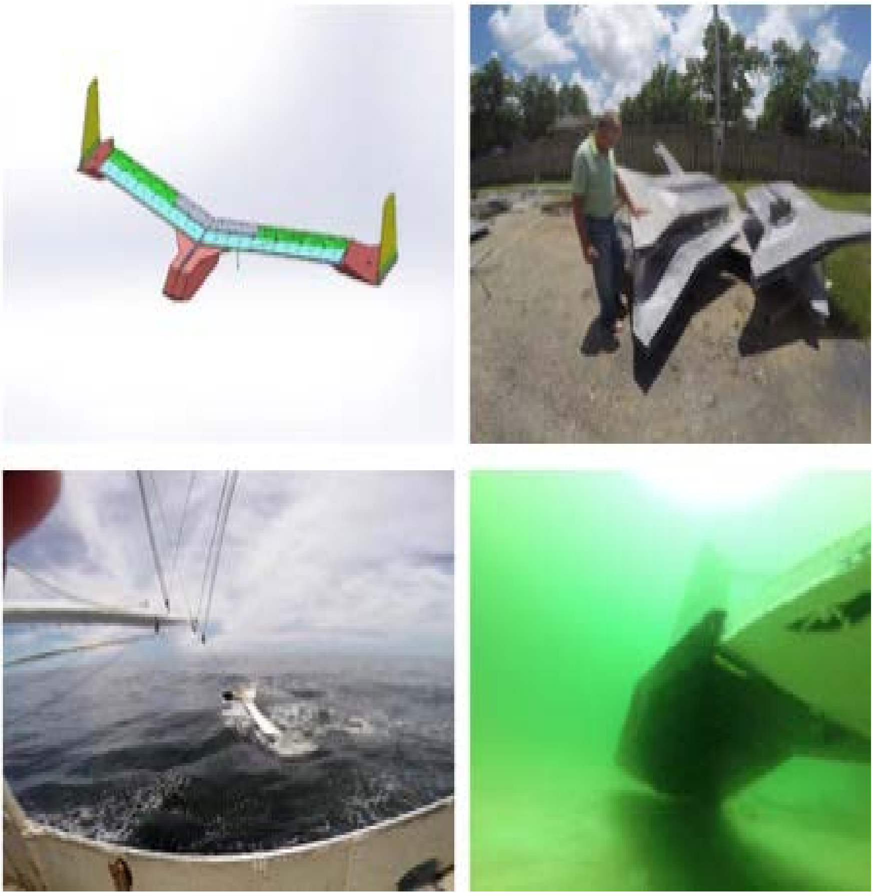

Figure 7.4.14. Wing Trawling System used for tropic shrimp trawling in the Gulf of Mexico (*images courtesy of Philip Walsh – Memorial University*)

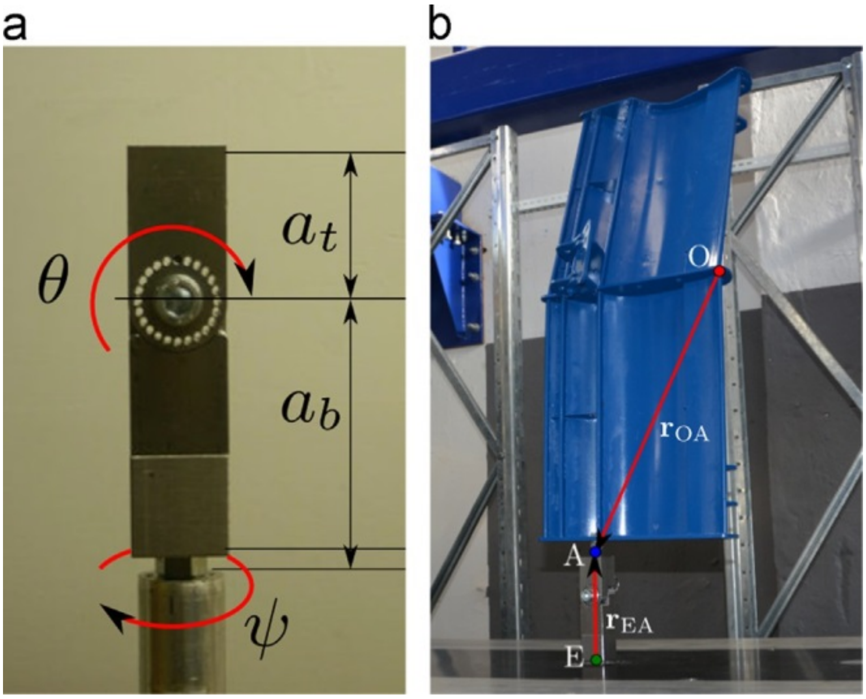

Figure 7.5.1. (a) Picture of the adapter and the orientation angles (ψ ; θ) of adapter. (b) Picture of an otter board installed on the adapter.

8 Topic Group: Non-Extractive Fisheries Sampling

Conveners: Shale Rosen and Haraldur Einarsson

8.1 General Overview

New observation technologies and collection techniques are making it possible to conduct some types of fisheries investigations without taking physical samples, or to collect small-directed samples from specific portions of a trawl haul rather than retaining all organisms that entered. Motivations for conducting studies without traditional capture methods may include investigations of populations with small numbers where the effect of removing individuals is of concern (Douglas, 1993; Nielsen, 1998) or restrictions in sampling in marine protected areas or areas inaccessible to traditional fishing gears (Merritt *et al.*, 2011; Williams, Roper and Towler, 2010; Williams *et al.*, 2014).

Multisampler systems which capture samples from specific portions of a trawl haul have undergone significant improvement and miniaturization since first described by Engås *et al.* (1997) (see Madsen *et al.*, 2012; Oozeki *et al.*, 2012). While the use of multisampler equipment does not eliminate the capture and mortality of all individuals, it can greatly reduce the sizes of catches if fish are directed out of the trawl between when codends are activated.

8.2 Terms of Reference

The topic group on Non-Extractive Sampling was a two-year Topic Group of WGFTFB, with participants attending workshop sessions at the 2015 meeting in Lisbon, Portugal and again at the 2016 meeting in Mérida, Mexico. Terms of reference for the topic group were:

1) Summarize current needs for non-extractive sampling (e.g. regulatory restrictions, sampling threatened or endangered species, sampling in sensitive or protected habitats);
2) Inventory currently available equipment and techniques;
3) Identify current gaps between available technology and sampling needs.

8.3 List of Participants in Topic Group Non-Extractive Sampling

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8.4 Summary of outcomes

During the 2015 meeting in Lisbon, the participants agreed that the group would focus on the use of visual techniques and modelling approaches. Topics such as tagging and passive acoustics were considered but excluded due to a lack of expertise within FTFB and small potential of replacing existing extractive sampling methods or likelihood for widespread use compared with visual and modelling approaches. The inclusion of modelling approaches was prompted by discussions of how to reduce the number of fish captured for selectivity studies, as the topics of presentations in plenary session and popularity of the ContactProbability topic group indicate this remains an area of significant work for the members of WGFTFB.

Regarding the first term of reference, in the experience of the members of this topic group the fisheries research community currently has a low level of concern about sampling mortality during routine investigations. The major drivers for the development of non-extractive sampling seem, rather, to be related to sampling in environments where traditional capturing gears are ineffective. A prime example of this is camera "trap" systems that can be deployed in habitats where mobile and even may static fishing gears cannot be deployed. In this case, a non-extractive method has been developed as a by-product rather than being the explicit goal. Considering the work of the ongoing WGFTFB Topic Group *Application of Change Management in the Fishing Industry*, the fundamental requirement for a sense of urgency to affect a change appears to be currently lacking. Given the strong focus on preserving time-series in fisheries surveys, there is little incentive to reduce sampling mortality without a clear scientific need or demand from society.

The group concluded that ICES CRR 312 *Fisheries applications of optical technologies* (Churnside, Jech, and Tenningen, 2012), prepared by members of the Fisheries Acoustics Science and Technology working group, provides a thorough and up-to-date review of both the principles and range of types of optical technologies applied in data collection in support of fisheries research and largely addresses the second term of reference. An area which has received less focus, but is equally important to the implementation of optical techniques, is developing and implementing methods for archiving and automating the quantitative analysis of video and still image data. Thus, it seems that the greatest gap between the technologies currently available (or at least those currently in use) and the needs of fisheries scientists is the tools necessary to extract quantitative data from image and video data in a time-effective manner.

8.5 Examples of Techniques and Applications

Video surveys

One application of non-extractive optical sampling common to a number of participants in the topic group is video surveys of *Nephrops norvegicus* based upon counts of both individuals and burrows. A system for automatic detection of both individual *Nephrops* and burrows is described in Lau *et al.* (2012). While the system generates false positive matches for both animals and burrows, the authors propose that it nonetheless greatly speeds up analysis time by eliminating "empty" video sequences and allowing a human analyst to focus on the sequences where potential animals and/or burrows are present.

Automatic detection of candidate features (left) and features classified as Nephrops or burrows (right) from video survey data. Figure from Lau *et al.* (2012).

Deep Vision (Rosen *et al.*, 2013) and Cam-Trawl (Williams, Towler and Wilson, 2010; Williams, Roper and Towler, 2010) are stereo camera systems designed to be placed inside trawls and image fish and other objects as they pass through. The Deep Vision system has been designed to optimize image quality for species identification based upon colour and shape while Cam-Trawl was designed primarily for use in surveys of Alaska pollock (*Theragra chalcogramma*) where species richness is low and species identification is possible based upon shape, texture and size. Example images from both systems are shown below:

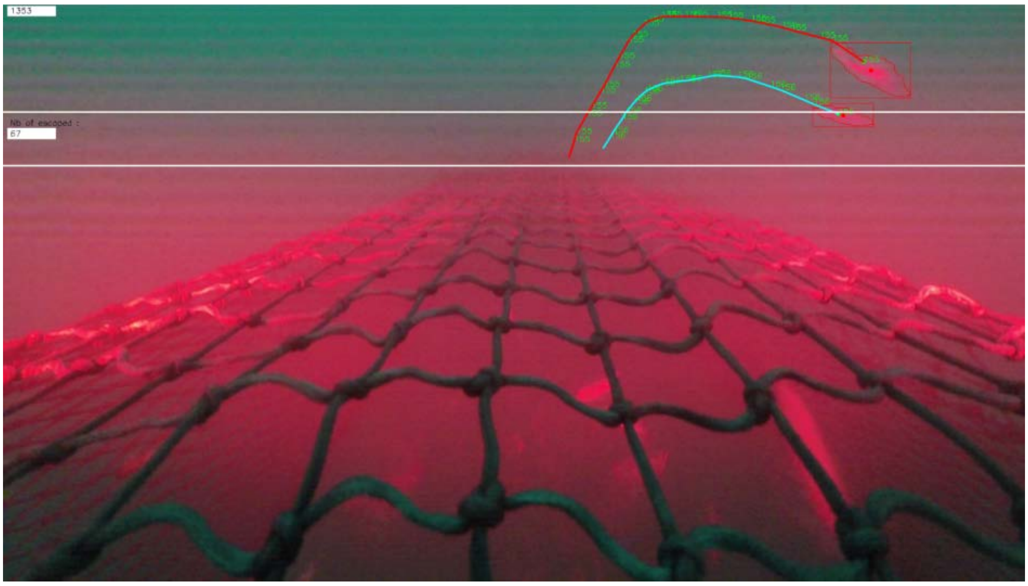
Example images from Trawl-Cam (left, from Williams, Rooper and Towler, 2010) and Deep Vision (right, from Rosen and Holst, 2013).

Currently, software can process Trawl-Cam data pick out individual fish and estimate lengths based upon an "oriented bounding box," with reported accuracy of 10% mean average error (Chuang *et al.*, 2011), although it is likely that accuracy has further improved since 2011. Species discrimination based upon "supervised feature learning" and "unsupervised species classification" result in up to 95% accuracy (Kresimir Williams, personal communication). Analysis of data from the Deep Vision system is still largely manual, although automation of both species identification and length measurement is under a testing phase. At present, species identification is carried out based upon visual inspection of the images by a trained technician and length measurements electing points on the snout and tail. Error in species identification (including fish not identifiable in the images) is less than 2% when compared to the catch in the codend, with maximum 10% error in length (85% of fish within 5% of length measured from the physical catch) (Rosen *et al.*, 2013).

A precursor to the Deep Vision system incorporated a mechanical gate for collecting a directed sample of fish based upon live video and control feed to the vessel (Rosen, Hammersland-White and Svellingen, 2010). A new sorting device is currently under design for integration with the Deep Vision system.

Analysis of moving objects (trajectory, speed, etc.)

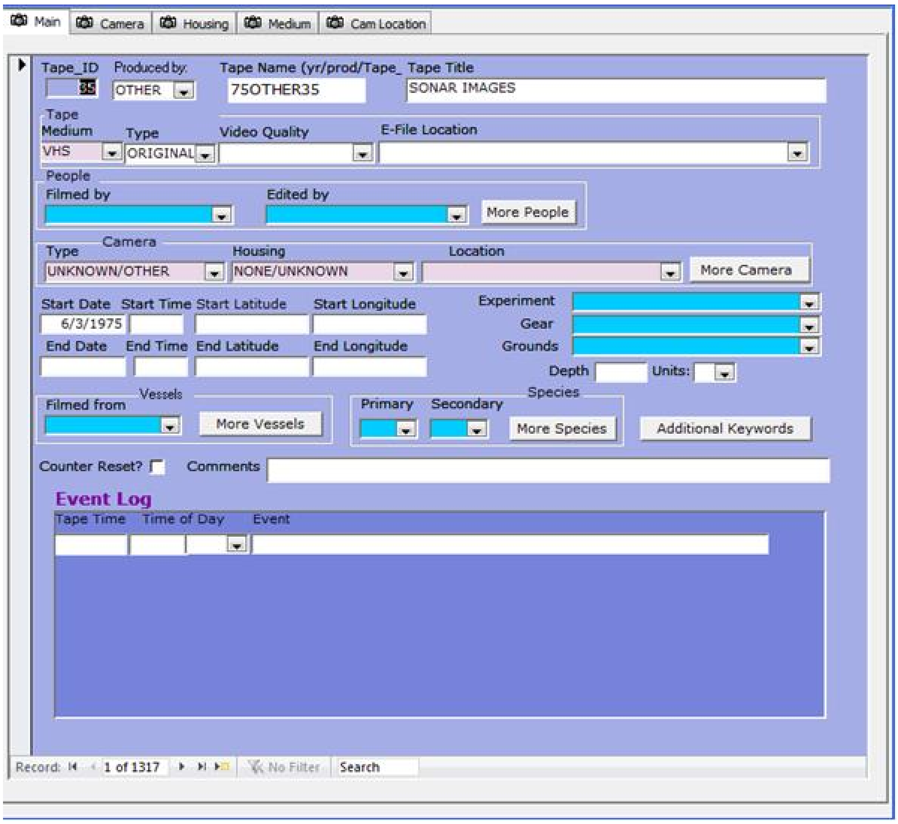
Another focus for automated analysis of images and video is object tracking. For investigations aimed at counting individuals, tracking is essential in order to avoid counting the same individual multiple times in sequential images. In behavioural studies, such as those conducted to evaluate fishing gears and bycatch reduction devices, metrics such as location, trajectory and speed of movements are important.



Fish escaping fishing gear detected and tracked as unique objects. From Mehault *et al.* (2016)

Data archiving

There are numerous methods for archiving both the source image and video data and data extracted from them. The simplest form would be some spreadsheet done in Excel or similar software. But such forms can quickly become complicated to use as the quantity of images and videos increases. A slightly more complex solution is some sort of "home-made" form to store data in connected tables using multipurpose database software. With such type of archiving, it is easier to maintain control over the video cataloging and analysis possess. The following figure is a screen-shoot of one type of these forms used by the Massachusetts Division of Marine Fisheries (USA).

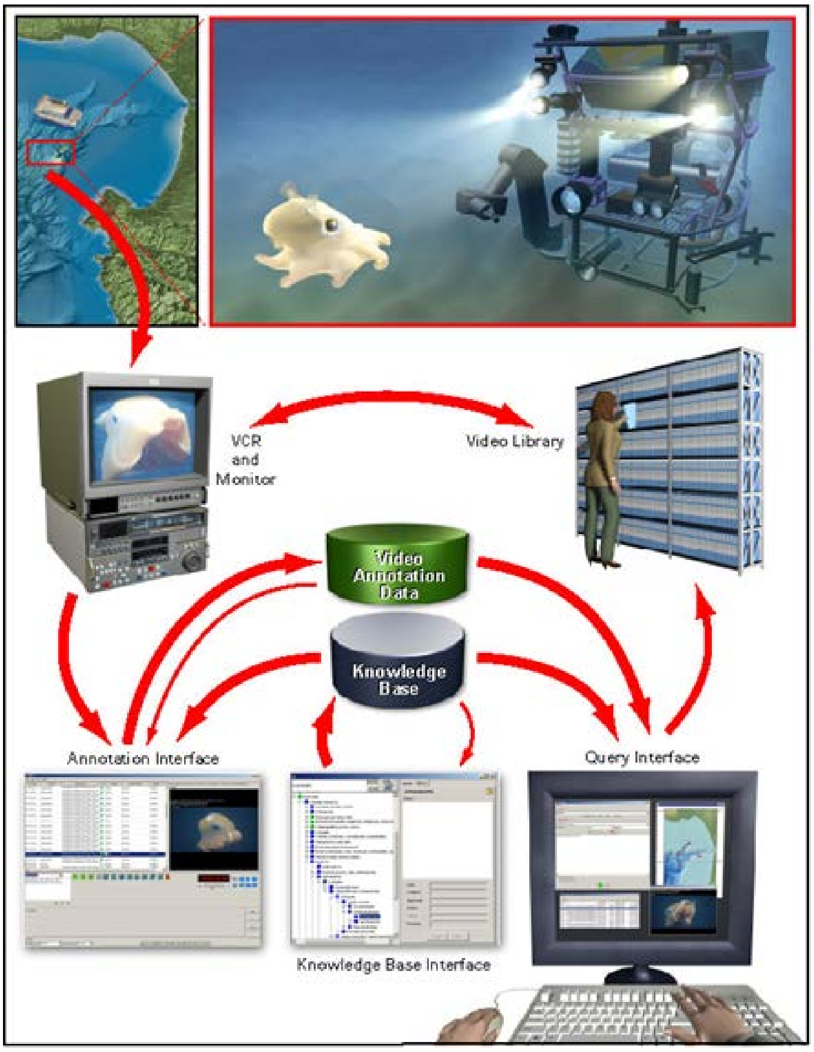


Screen-shot of form used by the Massachussets Division of Marine Fisheries (USA) for describe video and analysing process.

Examples of more advanced methods include specially programmed event logging software to link meta-data and coding of significant events with images and videos. This facilitates searching the database for specific events and returning to the images or portions of video of interest. One example of commercially available event logging software is The Observer XT (Noldus Information Technology, http://www.noldus.com/). An open source solution developed for cataloging and annotating marine video is the Video Annotation and Reference System (VARS, Monterey Bay Aquarium Research Institute

http://www.mbari.org/products/research-software/video-annotation-and-reference-system-vars/).

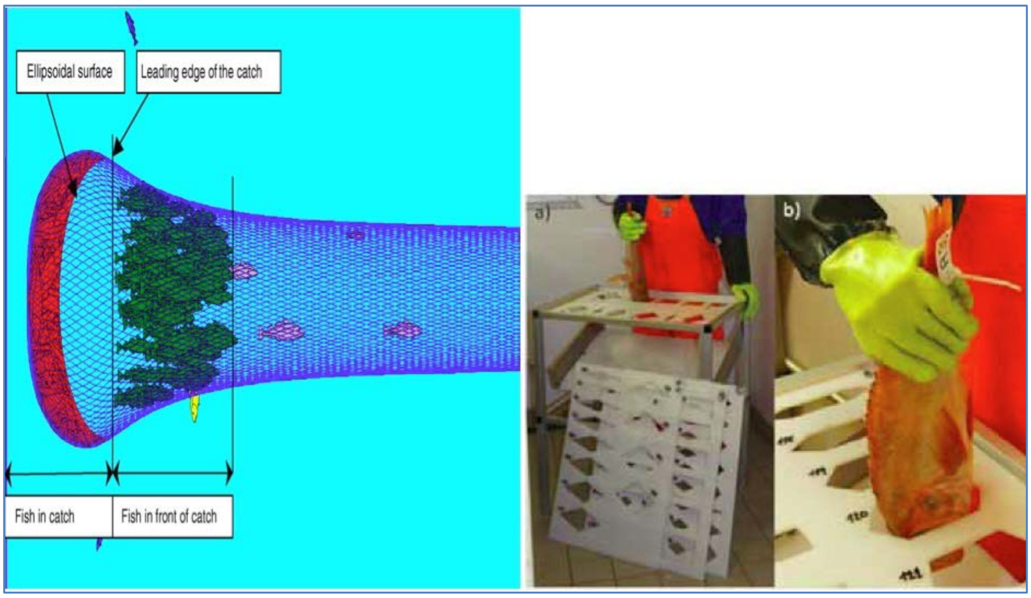
VARS is a software interface and database system that provides tools for describing, cataloguing, retrieving, and viewing the visual, descriptive, and quantitative data.



Flowchart of the Video Annotation and Reference System (VARS, Monterey Bay Aquarium Research Institute).

Modelling approaches to selectivity studies

Using simulation tools to understand and evaluate the selectivity and environmental impact of existing or new fishing gears and bycatch reduction devices can reduce the need for expensive and time-consuming sea trials and catches of fish. These tools can provide a cost-effective method to develop fishing gears with improved selectivity and reduced environmental impact. One example is the suite of SELNET, FISHSELECT and PRESEMO software's developed at the Technical University of Denmark. By modelling both fish morphology and the shapes of meshes in the codend of trawls during trawling, selectivity can be predicted without having to capture fish.



Left: modelling codend mesh opening using PRESEMO software (Hermann, 2005) Right: conducting "fall-through" experiments to determine what mesh sizes and orientations fish of given species and size can pass through (Hermann *et al.*, 2012).

8.6 Recommendations

The work of this Topic Group led to the conclusion that the uptake of non-extractive sampling methods is not so much limited by the equipment and methods to collect data in a less invasive way, but by difficulty in analysing the data collected. Researchers using camera techniques for fisheries investigations have common problems with storing video data in a proper database structure and expend too much effort in the form of manual human analysis of image and video data in order to extract quantitative data. Improving procedures for storing image and video data and automating post-processing would open doors to many other methods of collecting data on live marine organisms which are released unharmed after being recorded *in situ*.

Modelling gear selectivity through computer simulations is an area where the fishing gear research community has made steps to reduce the need to catch large amounts of fish. While field tests will likely be necessary to demonstrate the real-world characteristics of a fishing gear proposed for introduction into an actual fishery, modelling approaches can facilitate the "testing" of new fishing gear designs under development, saving time; expense and fishery resources.

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9 Topic Group: Application of Change Management in the Fishing Industry

Conveners: Steve Eayrs and Michael Pol

Summary

This meeting was the second of a three-year topic group on the application of change management in the fishing industry. It was attended by a total of 16 individuals from 10 countries. The purpose of this meeting was to retrospectively evaluate case studies related to change in the fishing industry against the Kotter model of change management, explore models of human behaviour that may contribute to resistance to change, and identify and categorize circumstances and approaches that led to the successful and unsuccessful introduction of change in fisheries. Seven case studies were presented, although not all were evaluated against the Kotter model. The group also explored two additional case studies, which were also evaluated against the Kotter model.

The main outcomes of the topic group were:

1) Retrospective case studies identified some or all of the steps of the Kotter model, but no particular step was considered to determine success or failure.
2) Elements of successful change programs were suggested: size of the stakeholder group, stature of participants, clarity of purpose or vision, closures or lawsuits forcing mandatory change (AKA "the hammer"), and health of fishery resource or profitability of the fishery.
3) Vessel ownership (non-operator/corporate vs. owner/operator) influences appetite and attitude toward change.
4) Readiness to change is an important element in understanding how change occurs, and can be a useful addition to the Kotter model, which focuses on inertia and process).
5) Simplification of regulations might engage fishers in useful innovation instead of harmful innovation.
6) Application of the Kotter model to two case studies highlighted the importance of a careful definition of the vision of a change initiative.
7) Contributions from social scientists with experience in human behaviour and the commercial fishing industry are needed in order to validate and support our understanding of human decision-making.
8) ICES Strategic Initiative on the Human Dimension (SIHD) should be informed of topic group findings and explore opportunities for collaboration.
9) Preparation of an extensive retrospective review for publication that attempts to categorize circumstances and events that contribute to successful and unsuccessful change initiatives in fisheries should be considered.
10) The group should present final findings and conclude the topic group in 2017, while seeking opportunities for future investigation and study.

9.1 General Overview

The topic group (TG) on Change Management in Fisheries met for the second year in Mérida on Thursday 28 April 2016. Sixteen people participated for part or entire of the meeting. Participants represented a wide range of experience, ranging from graduate students to senior personnel, and included work in large and small-scale fisheries globally. A preceding session ("Session 2: Encouraging technological change in capture fisheries") convened by Eayrs and Pol as part of the FAO Mini-symposium included six talks relevant to the TG, including a keynote by Eayrs on organizational change management that also introduced the TORs of the TG. In the 1-day available to the TG, the agenda, purposes, scope and objectives of the TG were introduced, followed by a series of presentations on application of the Kotter Model change management (Figure 9.1.1) model to instances of gear uptake or other change on historic or existing fisheries.

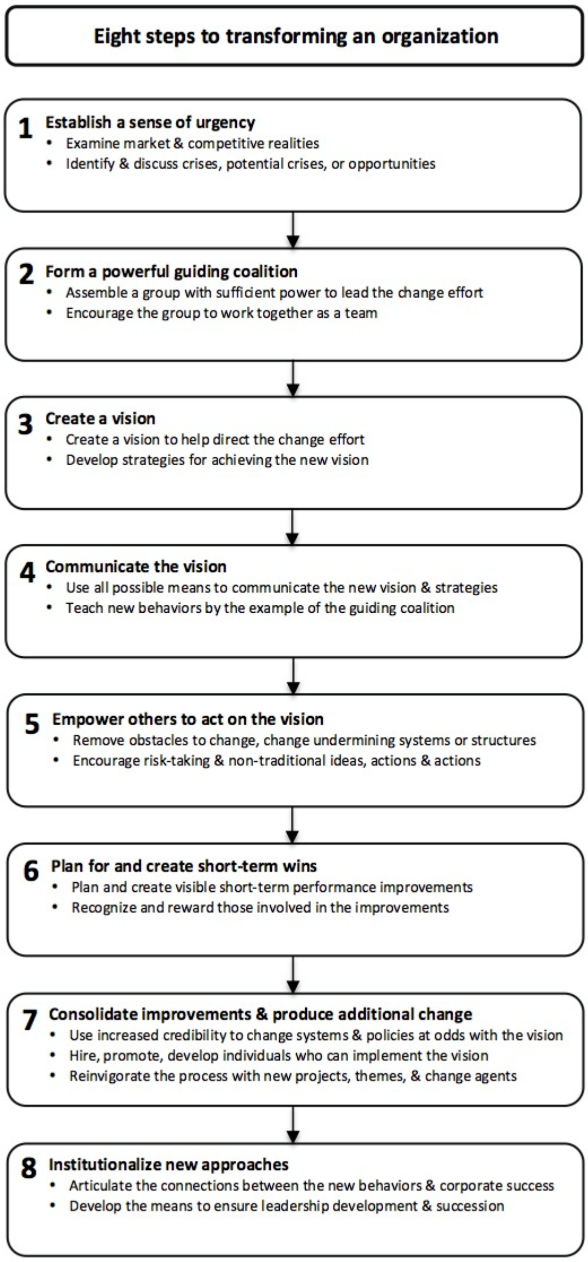

Figure 9.1.1. Kotter's eight-step change management model. (Adapted from Kotter, 1996.)

To set a foundation for the TG, Eayrs presented the agenda, purpose, scope, and objectives of the TG. He also summarized the 2015 meeting and intersessional action, and the Kotter model for change management. This model has been globally used in the business world and is considered applicable to the fishing industry. Seven presentations were heard by the group regarding the applicability of the Kotter model to past and current projects. Two case studies of imaginary or proposed activities were presented to subgroups and the Kotter model was used to test or to examine possible plans for implementation of these activities.

The retrospective application of the Kotter model gave some perspective on success or failure, although it was not found to be deterministic, nor was any one step of the model deemed crucial to success or failure; all were deemed important and necessary. A general discussion of possible motivations and explanations for resistance or willingness to change was conducted throughout the day, with economic rationality and discounting, the need for the appropriate size steering group, the health of the fishery, and the need for personal relationships and frequent contact all highlighted.

Future actions were left uncertain, because a need to involve social scientists to guide an understanding of human behaviour and decision-making is clear, but unfulfilled. If a social scientist is recruited for the TG in the following year, then the topic group will meet to discuss the third and fourth terms of reference; if not, either intersessionally or at the next TG meeting, a final report will be produced.

9.2 Terms of Reference

A WGFTFB TG convened by Steve Eayrs (USA) and Michael Pol (USA) will be formed in 2015 to evaluate the application of organizational change management concepts and models in a fisheries context and recommend new approaches to overcome resistance to change in the fishing industry.

The terms of reference:

1) Evaluate the applicability of organizational change management concepts and models in a fisheries context;
2) Review and evaluate fisheries case studies and initiatives to bring about change;
3) Explore models of human behaviour that may contribute to resistance to change;
4) Identify and categorize circumstances and approaches that led to both the successful and unsuccessful introduction of change initiatives in fisheries.

Justification:

Despite efforts by fishing technologists, conservation engineers, and others to increase fishing efficiency and reduce environmental impacts, commercial fishers are often highly resistant to changing their fishing gear and practice. In the business world, responses to change are increasingly being guided by organizational 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 provide an insight into new approaches to facilitate change in the fishing industry. By reviewing organizational change management literature, as well as past efforts to facilitate change in fisheries, we hope to identify circumstances, models, techniques, and approaches that will result in smoother, cost-effective, and successful change initiatives in the fishing industry in future.

It was noted that the first two terms were addressed the previous year in Lisbon, and that challenges with recruiting the assistance of a social scientist would limit our ability to address the third and fourth terms.

9.3 List of Participants

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9.4 Agenda

Time	Activity
0900 – 0915	Introduction – Agenda, purpose, scope, and objectives of TG; Housekeeping (Eayrs)
0915 – 0930	Introduction of participants
0930 – 1040	Summary of 2015 meeting (Eayrs) What role can organizational change management play in encouraging change in the New England groundfishery? (Eayrs) Technological change and the Kotter model: A case study with the raised footrope trawl (Pol) Reconversion of a trawler to a longliner to target black scabbard and hake (Theret)
1040 – 1100	Coffee
1120 – 1230	Implementing change in the North Pacific bottom-trawl groundfish fishery: sweep modifications success (Sethi/Hammond) Successsful Nordmore grid implementation in the Gulf of Maine shrimp fishery: external environmental analysis (He) Managing change in the Belgian fishery (Kinds)
1230 – 1400	Lunch
1400 – 1530	Technical measures in the Baltic Sea – an alternative to over-regulation and the brace-and-belt approach (Stepputtis) Case studies (2 groups)

	Graying fishers Dolly ropes
1530 – 1600	Coffee
1600 – 1715	Case study presentations Group 2: Graying Fishers presentation and discussion (Pol) Group 1: Dolly Ropes presentation and discussion (Zagorski) Wrap up discussion, next steps and future activity, and concluding remarks.

9.5 Presentation Summaries

Adoption of semi-pelagic Trawl Doors

Steve Eayrs - GMRI

This talk reviewed an initiative designed to encourage the uptake of semi-pelagic trawl doors and fuel flowmeters. Research testing the doors in the Gulf of Maine had measured a 12% fuel saving and no loss of catch. Fuel flowmeters were known to reduce fuel consumption by around 5%. A loan program with attractive terms and a $2500 rebate to fishers who purchase the doors and meter was made available to fishers, but few took up this opportunity despite many confirming the attractive terms of the program and record high fuel prices.

Overall the Kotter approach was not applied during the initiative described in this case study. No attempt was made to build a sense of urgency other than to remind fishers about high fuel prices and benefits of using the doors. It was assumed fishers would have a sense of urgency. No guiding coalition was formally established and leadership comprised primarily of project promotion by Eayrs and other GMRI staff, with occasional promotion by new makers and the fisher involved in the project. No formal vision was established, or communicated, other than to promote the benefits of the doors and the loan program via industry literature, e-mail, and word of mouth. Through the rebate fishers were incentivized to act and overcome fear; a semi-pelagic door program was also available for approximately 12 months for fishers to test the doors free of charge. Short-term gains included attracting for fishers to take advantage of the program and received a rebate, although few fishers have purchased these doors thereafter. Long term, few additional fishers have adopted these doors, usually following free testing of the doors, and culture has subsequently not been changed.

Members of the group considered that adoption of changes involved economic rationality, with discounting assessed individually based on perceived future fishing success. That is, fishers may be confident about long-term outcomes, and be more willing to invest resources in beneficial changes, or may be sensing imminent collapse of the fishery, and judge investment as inadequately profitable in the short term.

The relative complexity and utility of semi-pelagic doors were discussed, with different experiences. In Alaska, semi-pelagic doors were rapidly and voluntarily taken up, but it was unclear why this example involved such rapid uptake. In the Adriatic, the doors did not work well, and perhaps were harder to deploy and too complicated to rig and even to be explained. The need to monitor doors with acoustic sensors was mentioned, and while important, many fishers have adopted these doors without using sensors. This is a mixed message that hampers adoption. A struggle getting fishers to change to Dyneema netting was cited as a similar experience where obvious benefits were ignored and change did not occur, despite financial inducements. It was suggested that prioritization by fishers was a root cause for their behaviour, tempered by perceptions of complexity and lack of reward, and that timing of proposed change (including resource status) may be an important factor affecting successful adoption. The danger of initial bad experience poisoning any future positive experience was also mentioned.

An important question was raised about the timing of change initiatives, and how or if it is possible to identify the best time to introduce an initiative for maximum effect/uptake. The Kotter model does not explicitly consider timing, but inherently implies the amount of effort required to engender a sense of urgency (the first step of the model) is linked to the timeliness (readiness) of individuals to change.

Technological change and the Kotter Model: A case study with the raised footrope trawl

Michael Pol – MADMF

The Kotter model represents a possible framework for understanding how change comes about generally. Its application to fisheries has been considered and applied to several case studies. This talk reviewed the history of the development of the raised footrope trawl (RFT), an early example of a successful collaborative gear research program. This gear was implemented as a regulation and was broadly adopted. It continues to be used today. As a successful program, it provided a test case for the applicability and utility of the Kotter model, with some retrospective insight into successful testing and uptake. The impetus for change was the closing of the fishery in 1995, a condition that seems to inspire uptake. The guiding coalition comprised of the Massachusetts Division of Marine Fisheries and members of the fishing industry. The creation of a vision to reopen the fishery required trawl gear to reduce bycatch to 5% of regulated species by volume, although it was not formally articulated as a “vision”. Communication involved meeting fleet participants, sharing ideas for new RFT gear designs, and a requirement for self-reporting. Empowerment included allowing fishers to test new gear designs while under permit restrictions, self-reporting of results, and informal tinkering of the RFT to suit individual needs. This combined with flume tank testing and information exchange could be considered as short-term wins. The successful use of this trawl produced additional change for altered boundaries to fishing grounds and ultimately resulted in the new gear being widely accepted. It was concluded that the retrospective application of the Kotter model provides important insight into the process of gear adoption and a possible framework for future actions. It was also noted that despite being unaware of this at the time, that many steps of the Kotter model had inadvertently been applied to a greater or lesser extent.

A technical question on the rigging of the chains in this net was asked.

Conversion of a trawler to a longliner to target blackscabbard and hake

Francios Théret - SCAPECHE

This presentation described a comparative fishing experiment following the conversion of a trawler to a longliner. It did not link the application of this initiative to the Kotter model primarily because of the comparative nature of the experiment.

One vessel was subsidized for conversion, with the hypothesis that longlining would save fuel, be more efficient, and have no bottom impact. The fishery is a new one, so gear has not been refined or perfected. Catches were not profitable. Crews had different reactions depending on previous experience; many trawl fishers did not like the repetition/boredom associated with longlining. Markets were also new. Improved quality did not result in higher prices to the vessel. Longlining was found to be less efficient than trawling, and it was hoped that with more experience fishing, and refinement of gear, it could become profitable.

It was asked if any plans were being made to encourage additional conversions. It was felt that if the conversion were profitable, no encouragement would be necessary.

Implementing change in the North Pacific bottom-trawl groundfish fishery

Suresh. Sethi (Cornell University) and Carwyn Hammond – NOAA SFSC

This presentation focused on the uptake of trawl sweeps by the North Pacific bottom-trawl groundfish fishery in the Bering Sea and described the process retrospectively against the Kotter model. Alaskan fisheries were urgently seeking reduction of fishing gear impacts in reaction to the need to protect essential fish habitat as required in the Magnuson Stevens Act. NGOs and other stakeholders were also advocating habitat protections in the area and the fishery. A coalition of a few key individuals was formed that included regulators, scientists, netmakers, conservation engineers, and industry. No single vision was created – the change was reactive and not part of a cohesive vision. A plan to seek funding to test the gear modifications contributed to communication of a vision to reduce habitat impact, driven by the coalition. Field tests citing favourable results and their communication to the Management Council and others helped clear a path leading to the adoption of this gear. Several short-term wins were identified including reduction in bottom contact to essential fish habitat and reduction in unobserved mortality in commercially important crab. Use of the sweep gear was institutionalized by the Council and fishers are using this gear currently; similar work is unfolding in the Gulf of Alaska as a direct result of the success of this program.

The unique characteristics of the Alaskan fishery were cited as reasons for a successful outcome, in response to a question about why change had seemed to unfold quickly and efficiently, compared to s in New England where it is often (seemingly) more challenging. Possible reasons for these differences include: The ownership by large companies encourages a long-term view and investment; skippers work together and are professionalized; personal relationships matter, with trust among captains, gear scientists, and netmakers supporting development and testing. Finally, the relative health of the fish stocks and the profitability of fishers involved in this work were also suggested as a possible explanation for their success.

Successful Nordmøre grid implementation in the Gulf of Maine shrimp fishery: External environmental analysis

Pingguo He – University of Massachusetts Dartmouth

An attempt to analyse the rapid (seemingly "overnight") implementation of the Nordmøre grid in the Gulf of Maine shrimp fishery was presented using a "strategic readiness" model. Assessing a situation from multiple angles and perspectives (political, economic, social, technological, legal, and environmental) identifies the starting place and willingness to change. *Politically*, the shrimp fishery was declining and pressure existed to close the fishery, including from the groundfish fishery, which was experiencing declining fish abundance and was concerned over landings of groundfish by shrimp fishers. *Economically*, a fear of loss of revenue from the fishery was balanced by potential loss of marketable fish if bycatch was reduced. Furthermore, an ability to reduce the number of deckhands sorting the catch was viewed by many fishers as an attractive option. *Socially*, the fishery was perceived was viewed negatively as "dirty" by the public. *Technologically*, the grid was successfully tested and implemented in Norway in the 1980s. This development followed a period of approximately 10 years' testing of other bycatch reduction devices, and concerns over hazards of handling a 'hard' grid. *Legally*, NGOs sued NMFS on the persistence of overfishing on groundfish. *Environmentally*, the cod moratorium in Newfoundland created fears of a similar closure in New England, particularly at a time when groundfish abundance was declining (it should be noted that many groundfish fishers also fished for shrimp). Based on this model, the industry seemed prepared and ready for change and rapid uptake of the grid ensued. Mandatory use of this grid occurred within a six-month period, an unusually short period, but it remains unclear how or if the circumstances could be applied to other fisheries and realize similar outcomes in a short period.

The strength of regulation was argued to be a major contributory factor affecting the adoption of new gear by fishers, because the playing field was level - all shrimp fishers had to change, not just a few. The threat of lawsuits was cited as another key driver for gear change and adoption. There was general agreement that the big stick approach (or "the hammer"), such as impending regulation or lawsuits provides a strong sense of urgency and extreme incentive to change while economic inducements less so.

Managing change in the Belgian fishery

Arne Kinds - ILVO

This presentation focused on two projects, although the primary focus was the VALDUVIS project that involved fishers and other stakeholders in a voluntary tool to assess, visualize and monitor the sustainability of the Belgian fishing fleet based on individual fishing data. This project commenced using a multi stage framework that included a scoping phase, followed by an envisioning phase, then experimentation, monitoring, and evaluation phases. Within the scoping phase stakeholder identification, vision development, and problem identification are core components. The envisioning phase comprises of identification of possible sustainability scenarios, followed by development and testing of sustainability indicators (that is, experimentation). Following their introduction to the fishing fleet, the indicators are implemented and their efficacy evaluated. An incentive for fisher involvement in these projects was market access. An outcome of the projects was a multidimensional rosette plot to inform vessel owners and operators, to monitor progress toward sustainability goals based on a suite of identified sustainability criteria, to identify potential policies and research, and to inform buyers.

The Kotter model was used to retrospectively investigate slow uptake by the broader fleet and stakeholder groups. A lack of true urgency was identified as a barrier – a need existed, but the role of stakeholders was unclear, and the overall project was ambitious and unrealistic, with unclear outcomes. Risk of losing market access was real, but was not adequate to develop a sense of urgency by fishers. A successful guiding coalition was built, including a steering group that met several times each year, with five fishers with close ties to the producer organization (responsible for day-to-day management of fisheries, application of Common Fisheries Policy, and communications between policy-makers, researchers, and fishers). They were also kept well informed of all project developments. The project included a visioning stage that was fine-tuned via a cyclic approach over time. Communication among the stakeholders appeared to be adequate and thorough, but the lack of clarity of the vision was again highlighted. Communication included information exchange with fishers and publication in industry literature. Obstacles to change and empowerment were not fully understood, and included resistance and criticism from multiple sources. Short-term gains were unclear and rewards to fishers such as financial gain were perceived to be realized in the long term, so the worth of extra effort was not immediately recognized. A new project to produce additional change is proposed, and it was seen that a greater interaction with fishers to implement the vision was needed, including individuals dedicated to implementing the vision through close relationships and communication with fishers, as well as greater clarity of individual roles. Finally, while new approaches were not institutionalized, progress continues including greater communication of success, and greater focus on step-by-step implementation. The assessment of fisheries by MSC is considered an option that has changed the dynamics somewhat but raises the question if both systems can coexist.

A comment was raised regarding New Zealand fisheries serving as examples of introducing seemingly rapid change, given their strong centralized government, prevalence of eNGOs, catch value, and quota based management. In response, it was suggested that these fisheries seemed no more adept at changing rapidly than fisheries elsewhere. Further conversation included the importance of considering that change in response to a management action may occur more quickly than change that is voluntary, such as fuel saving options, or environmental impact reduction. Additional discussion centred on measurement of success, and that sometimes success is difficult to measure or appreciate, partly because the vision is poorly articulated upfront or unclear.

Technical measures in the Baltic Sea – an alternative to over-regulation and the brace-and-belt approach

Daniel Stepputis - Thünen Institute of Baltic Sea Fisheries

A review of regulations in the Baltic Sea was presented, with examples of what should be maintained, removed, altered, or developed. The chilling effect of overcautious, complex fishery management and unnecessary regulation was emphasized. For example, with the introduction of the discard ban, many gear measures can be removed such as codend regulations, minimum landing sizes, and effort restrictions, otherwise conflict between ‘old’ and ‘new’ rules is inevitable. It was argued that the brainpower spent on accommodating (and sometimes circumventing) regulations by fishers could be harnessed to facilitate change and solve more important questions if regulations were rationalized and simplified.

9.6 Case Studies

The topic group participants were divided into two subgroups, and given separate topics to consider using the Kotter Model. The groups were provided with additional material expanding understanding of the model. They devoted approximately one hour to discussion and reported back to the group at large.

Dolly ropes

The group viewed a video (http://www.dollyropefree.com/) which is an industry attempt to reduce loss of plastic threads from dolly ropes. These ropes serve to protect trawl codends from abrasion on the seabed; however, over time they become worn and strands are often lost at sea. Based on the video, it was felt that a sense of urgency was not established, but instead the video served as a warning to fishers and that they should take steps to avoid loss. A strong guiding coalition was not apparent;

some fishers argued for change, but no insight was gained into the expertise and number of fishers involved in the video. It was also not clear if other stakeholders were involved. The vision was established, and it was simple and straightforward: to reduce loss of dolly ropes. Communication was achieved thru the video but it was not clear if other communication was attempted, what results were expected, how they would be collected, and where they would be used. Empowerment was seemingly modest, simply limited to a plea for others to join their efforts. A clear message was required, including why others should participate. Short-term wins were absent from the video. They could have promoted dolly rope free activity, perhaps even considered dolly rope free certification. Encouragement of new designs to replace dolly ropes was weak, and no milestones or time frames for success were obvious. Consolidation of improvements was absent, and no cultural change, or institutionalized changes was apparent. They could have also expanded to all plastics dumped at sea.

It was suggested that the Kotter model provided an interesting and fresh way to look at a problem or issue in fisheries, a problem that is important to tackle appropriately, and that the model highlighted certain deficiencies in their approach, which might otherwise be missed and might contribute to their success or lack thereof. It was also suggested the video may have been seeking additional involvement and was not designed to provide a fuller perspective. The intended audience was not entirely clear, facilitated by seemingly conflicting messages and statistics that were unclear.

Ageing of the fleet

The group was asked to develop a plan of action following the Kotter Model to address the problem of an aging fishing fleet. This problem had been identified as occurring across the USA including Alaska, as well as other countries.

The group recognized the problem but quickly identified that to deal with it a clear vision was necessary. They noted that 'a vague statement but good intentions' is not an ideal starting point to deal with an issue, but that a clear vision was essential. They then realized the problem is not just about the fleet getting old, but maintaining of the economic health of a fishery, as a fleet dominated by older fishers risked under exploitation of the resource if they were not replaced. The "true" problem was therefore interpreted to be barriers to entry by young people, heavily influenced by the health of the resource – few new fishers when fishery health is poor, costs of quota, vessels and licenses, perceived status associated with employment as a fisher, perception that fishing is hard work, and pay is poor, lack of training, and complex fishery regulations. The importance of understanding the vision was considered when identifying a sense of urgency, although the possibility of creating a false sense of urgency based on emotional reaction to the problem was considered. A vision was presented and discussed:

- An economically stable and sustainable fishery (as well as the knowledge base to exploit it) and a robust age structure in the fleet by increasing accessibility for younger people to enter the fishery.

An alternative was provided and discussed, based on the notion that a vision should be sharp and concise:

- Increasing accessibility for younger people to enter the fishery.

To build a coalition, older fishers mentors, young successful fishers, and financing experts were identified. The need to attract younger people to training and courses via updated curricula and content was discussed. Additional Kotter steps could not be addressed in the provided time.

9.7 Discussions

The group were provided an opportunity to provide final thoughts or discussion points. One participant spoke of a colleague that is applying a so-called Pre-mortem approach ("project has died before it has started") whereby he envisions the project has gone wrong, then envisions why it might have gone wrong, and then creates a plan in place to take remedial action. This was suggested worthy of further consideration by group members.

A so-called 'super' model was presented by Eayrs to guide discussion about possible next steps. The model combines Kotter (with its focus on process and inertia), and other models that consider the constructs of change readiness and time, which are not clearly apparent in the Kotter model. Change readiness was posited as a possible future direction for the group, and through questionnaires, it is possible to evaluate cognitive and affective change readiness. This gets to important constructs such as discrepancy, appropriateness, efficacy (that a way can be found to solve the problem), support (is it available and adequate?), and valence (that it relates to them).

The group discussed how much further we could go given our limited expertise in human behaviour and a need was mooted to invite social scientists to contribute to the group. Is a workshop between this group and a social science ICES expert group a possible step forward? Should we reach out to the ICES human dimensions group or other group? Can models of human behaviour help guide options to facilitate change? Concerns were also raised that the meeting next year in New Zealand would limit continuity of the group and hamper achievement of planned Topic Group outcomes due to the expense and time of travel to a remote location.

Additional discussion centred on a need to search for case studies to identify/categorize why change was successful or otherwise, and to use this outcome to help inform future change initiatives. Such an approach could be small or large-scale and would also help identify key attributes for success that could be the target of future efforts, and which would further help validate the efficacy of the Kotter model in a fishing industry context.

9.8 Recommendations

1) The group will work intersessionally to recruit a social scientist with experience in fishing gear/collaborative research, possibly from New Zealand or nearby the meeting location. Input from a social scientist will help validation and support our understanding of human decision-making and to meet the third term of reference.
2) We will inform ICES Strategic Initiative on the Human Dimension (SIHD) of findings of the topic group and seek opportunity for further collaboration.
3) A retrospective review/manuscript of prior successful and unsuccessful studies via literature and personal experiences, with respect to change models, would be useful for members of WGFTFB, and may be completed by members of the TG. It would help describe what seems to work and what seems to not work

4) The conveners and others will reach out to social scientists, alert them of our progress and need, build bridges, complete our TOR next year and then concentrate on working closely with other groups to help address outstanding TORs. If a social scientist is recruited, the group will meet in 2017 and fulfil the remaining terms of reference. If not, then we will prepare a final report in the intersession.

10 Topic Group: Contact Probability of Selective Devices

Conveners: Daniel Stepputtis and Bent Herrmann

Summary of Findings

The main purpose of this topic group was to increase the awareness of successful contact between fish and selectivity device (as basis to make the selectivity device working) and to discuss the work related to contact probability. During the two meetings of the topic group (2015 and 2016) a number of examples were given, were contact probability was a) investigated and estimated and b) played an important role in the functioning of successful selectivity devices or c) was a likely reason that a developed selectivity device/concept did not worked as desired. Therefore, a large fraction of the topic group meeting was spent to show and discuss intensively different devices/concepts/underwater video recordings etc. The topic group participants stated during and after the meeting that especially these intensive (and mostly informal) discussions made the topic group meeting a success.

A more detailed investigation and discussion of contact probability between fish and selection device is essential to further improvement of existing and the development of new selective devices. This is also reflected in the numerous contributions to this topic group. In addition to the general investigation on the contact probability for a given selective device, the information on the contribution of different factors, influencing this contact probability is often missing. Only very few studies investigated/ estimated such influencing factors.

10.1 Introduction

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 is 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. Therefore, a WGFTFB topic group of experts was established in 2015 to investigate, understand and improve the contact probability of specific selective devices (e.g. grids, netting). The TG 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.

10.2 Terms of Reference

1) Summarize current and past work in relation to contact probability
2) Discuss and describe methods (experimental and statistical) to investigate and quantify contact probability

3) Investigate and make recommendations on how to improve contact probability in selective devices, including
   - 3a) Identification of gears and selective devices with suboptimal contact probability (preferably based on current gear trials from group members)
   - 3b) Discussion on potential causes and solutions
   - 3c) Recommendations on experimental/theoretical work to understand and improve the contact probability

10.3 List of Participants

During both 2015 and 2016 meetings, the interest in this topic group was significant. In the 2016 meeting, 17 scientists participated in the topic group "contact probability" (Figure 10.3.1).

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10.4 Summary of the 2016 Meeting

The meeting of the TG was held on 28 April 2016. The focus of this second meeting was (as continuation of the meeting in 2015) to review the current status of research. Therefore, participants presented their past and current work related to this topic in informal presentations. A total of 14 presentations of selectivity devices, concepts, underwater observations, methodological concepts were given during the meeting, whereas the main focus was the informal and stimulating discussion during the meeting.

Whereas in 2015, the understanding of the general concept and definition of "contact" (including "effective contact" and "qualitative contact") was a main issue, in 2016 the definition and examples given in 2015 were successfully applied during the discussion (the summary of the 2015 discussions of a "contact"-concept is given below).

The "Contact" Concept

The "**contact"** leads to a size dependent escape probability through the device which is relevant and for which we can estimate the value. With this definition, a fish that makes physical contact with the device but does it with a very poor orientation for escapement through the device will be accounted as not making contact (contact = 0).

This basic definition did lead to the discussion about specific examples for reason for lack of contact. For example:

1) Fish get in (physical) contact with the grid, but due to some reasons (not selective properties of the selection device) it is not able use the device, e.g. due to:
    a) Wrong orientation to the selective device, e.g. sliding along a grid;
    b) High water flow, reducing the time of escape attempts;
2) Fish try to use the selective device but is able to swim out and in (and out and in and out and in).

Both examples show that the basic definition (and the methods we use to calculate contact does not take into account the complex structure of processes which can result in the final contact probability (e.g. in-out-in-(out) is measured as binomial event). Therefore, an improved knowledge of contributing processes can lead to a better understanding of the entire process as basis for the improvement of the gear. Additionally, this process can be potentially influenced by a number of parameters which are seldom taken into account in gear selectivity investigations. These parameters include:

1) Gear related
    a) Design of gear/selection device
    b) Movement of codend/selection device (e.g. important for T90 vs. T0)
2) Fishing process
    a) Depth
    b) Catch volume
    c) Water flow
3) Environment
    a) Seasonal effects (see below abstract from O'Neill *et al.*)
    b) Temperature
    c) Biology of fish (e.g. condition, maturity status)
    d) Turbidity
    e) Light
4) Behaviour of specimen in relation to the gear

Examples of presentation at the 2016 meeting

The presentations giving during the 2016 meeting showed many examples on size selection in trawls where contact probability with a selection device played a key role for the efficiency of the device. Some of the presentations did show photos of different devices, other presentations focused on underwater recordings demonstrating what fish behaves near to the selection devices while other presentations provided quantitative results for the efficiency of the devices. The examples given covered a larges range of different fisheries in Europe but also examples from South America. To illustrate this variety of devices, fisheries, species and type of information provided and discussed during the 2016 meeting Figure 10.4.2.1 to 10.4.2.12 below provide summary slides from selected presentations.

10.5 Recommendations

The work of this topic group needs to be continued. Both conveners of this Topic Group may have problems to join the WGFTFB meeting in 2017 in New Zealand. If this is the case, it is recommended that this topic group be postponed until the 2018 meeting.

Figure 10.3.1. Photos from the 2016 meeting in the topic group "contact probability"

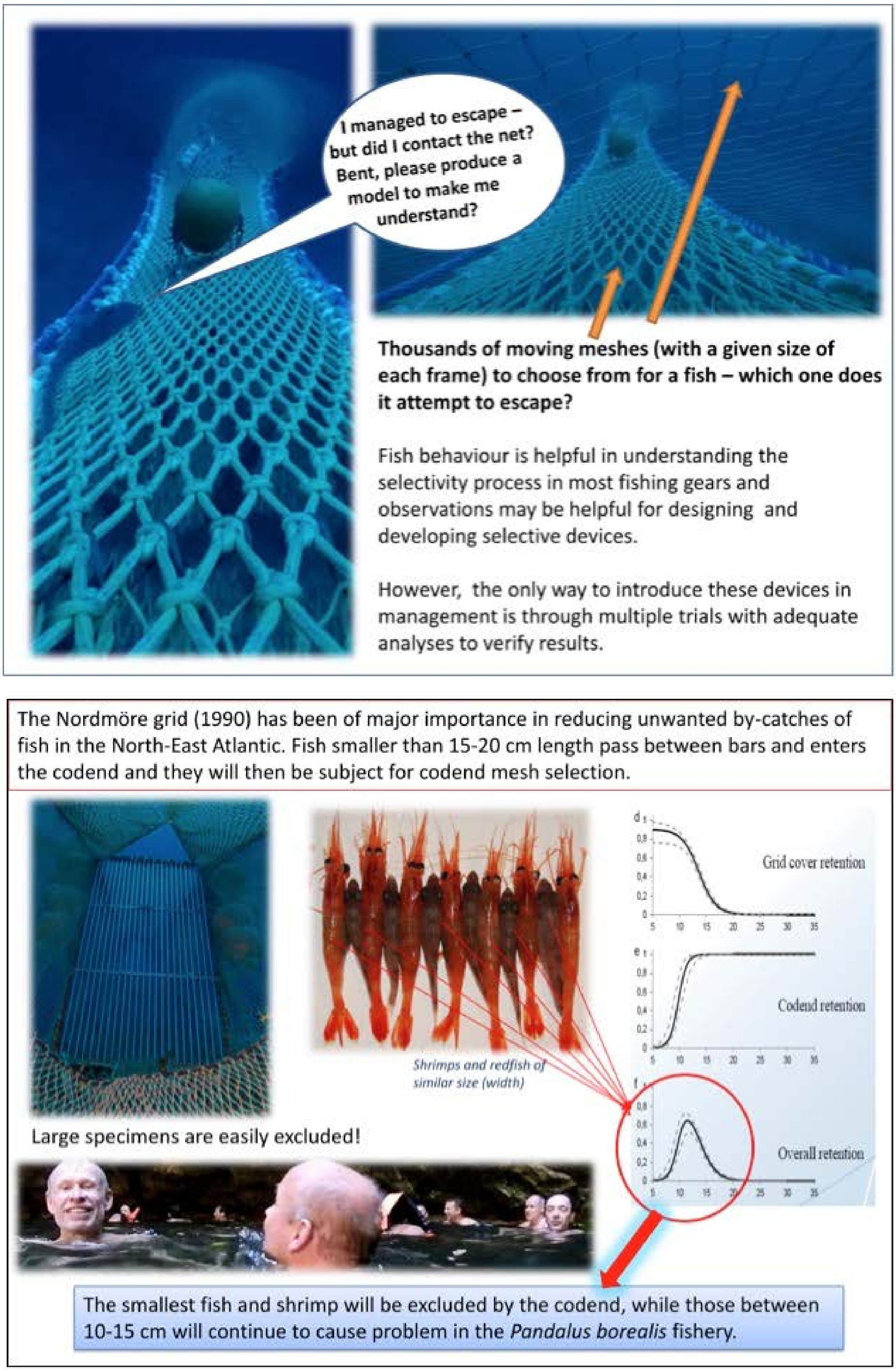


Figure 10.4.1. Summary of presentation, given by Roger B. Larsen (The Arctic University of Norway; Norway): Norwegian selectivity experiments (e.g. grid systems) and Contact probability as a driving factor for success.

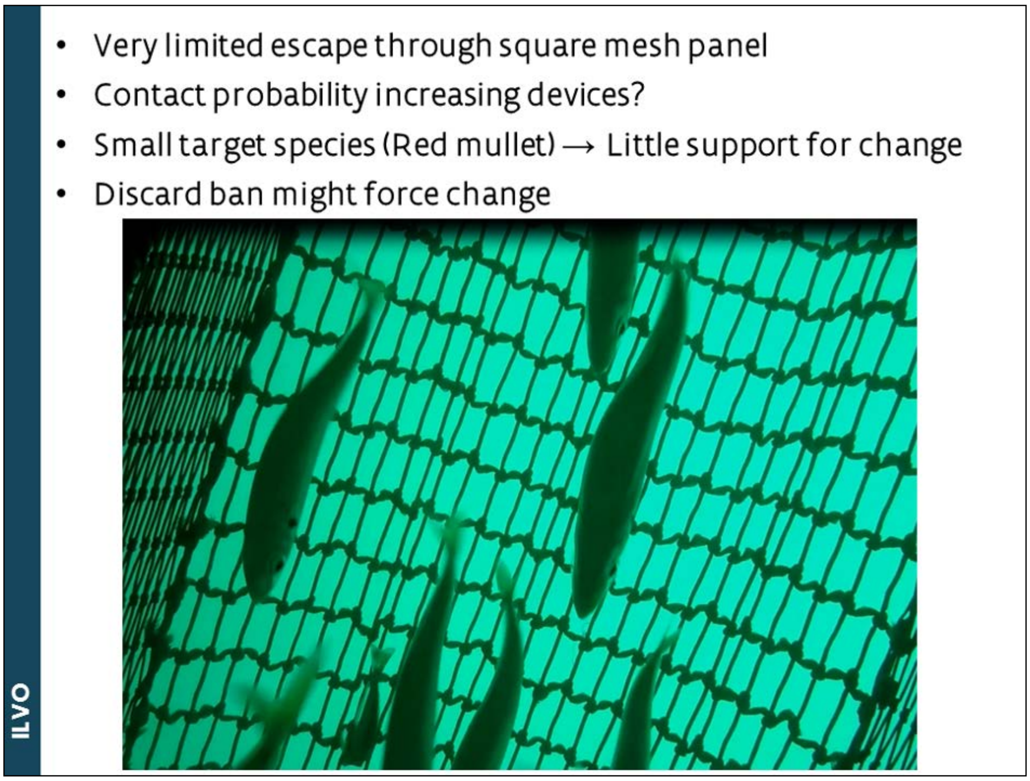


Figure 10.4.2. Summary of presentation, given by Bart Verschueren: The efficiency of square mesh panels in Flyshooting Fishery, intensive discussion about underwater recordings.

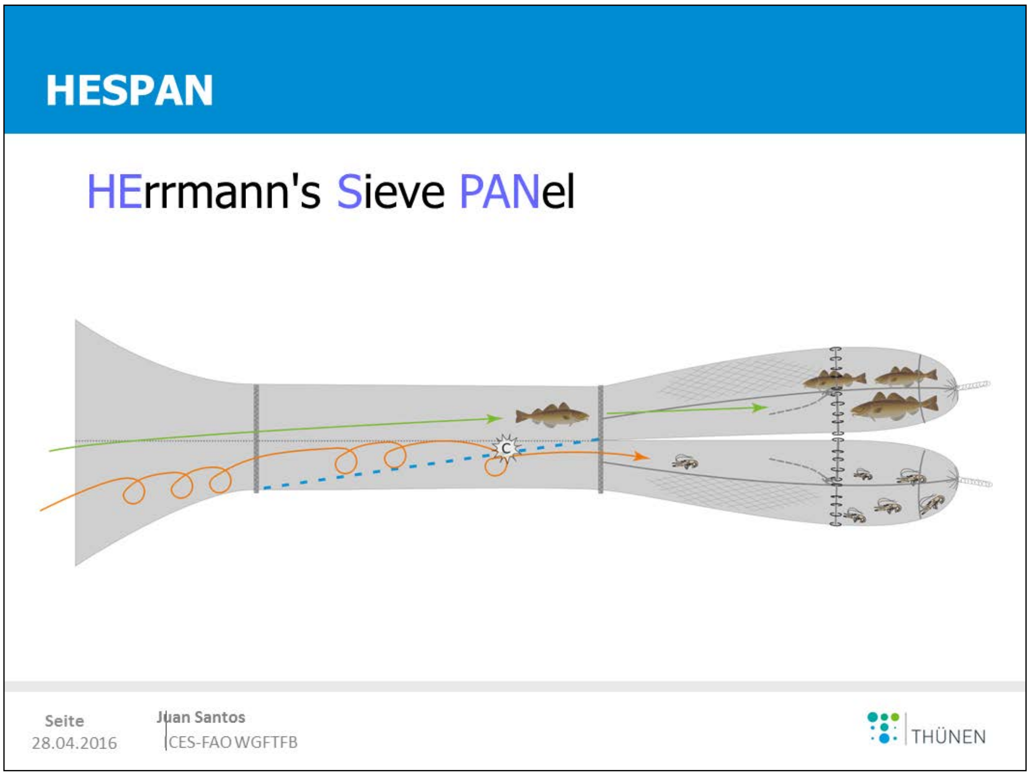


Figure 10.4.3. Summary of presentation, given by Juan Santos (Thünen-Institute of Baltic Sea Fisheries; Germany) (Slide 1): Schematic drawing of a selection device to separate *Nephrops* from fish (HESPAN).

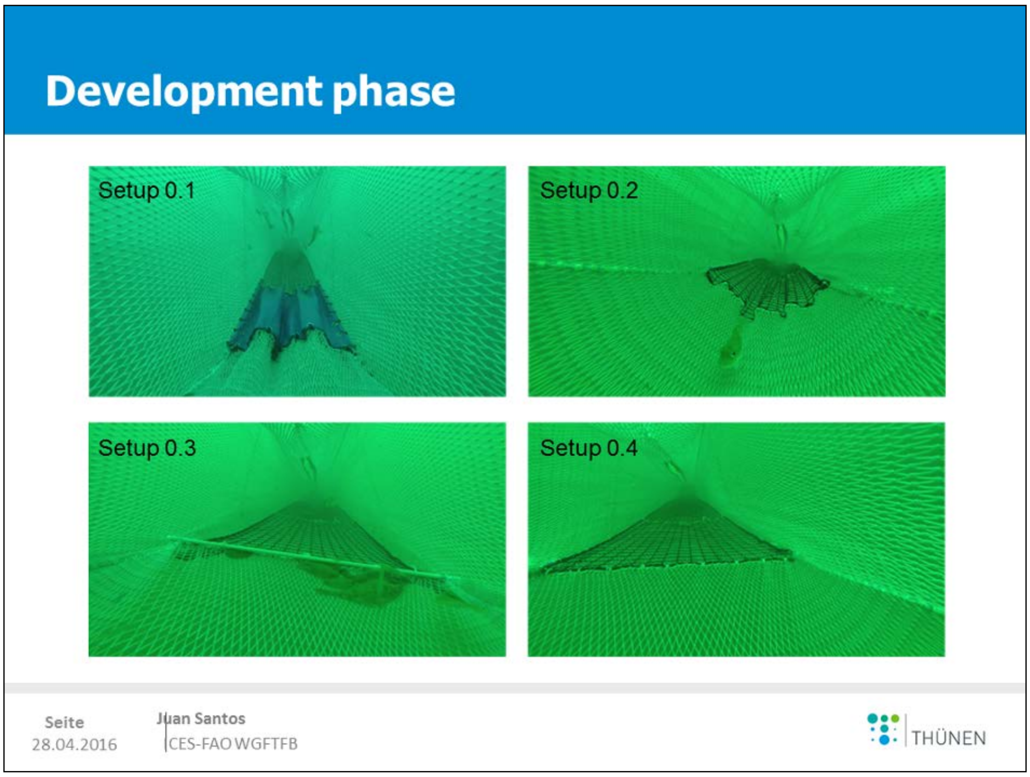


Figure 10.4.4. Summary of presentation, given by Juan Santos (Thünen-Institute of Baltic Sea Fisheries; Germany) (Slide 2): Different HESPAN-setups tested (underwater recordings).

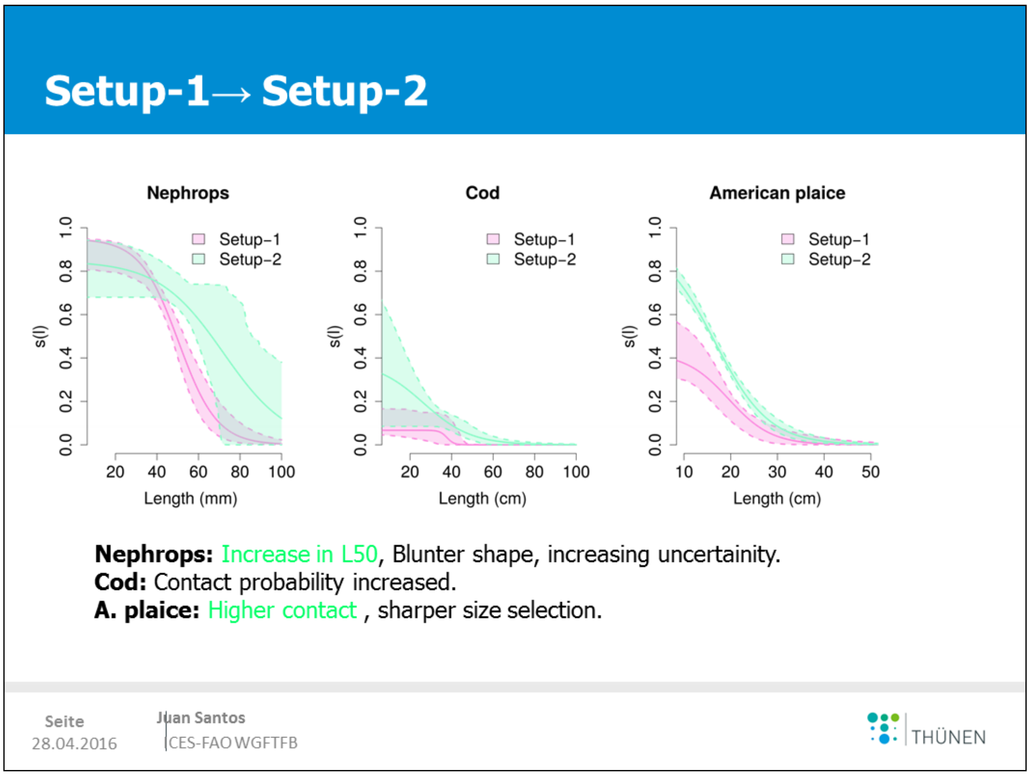


Figure 10.4.5. Summary of presentation, given by Juan Santos (Thünen-Institute of Baltic Sea Fisheries; Germany) (Slide 3): Example for results, obtained with different HESPAN designs.

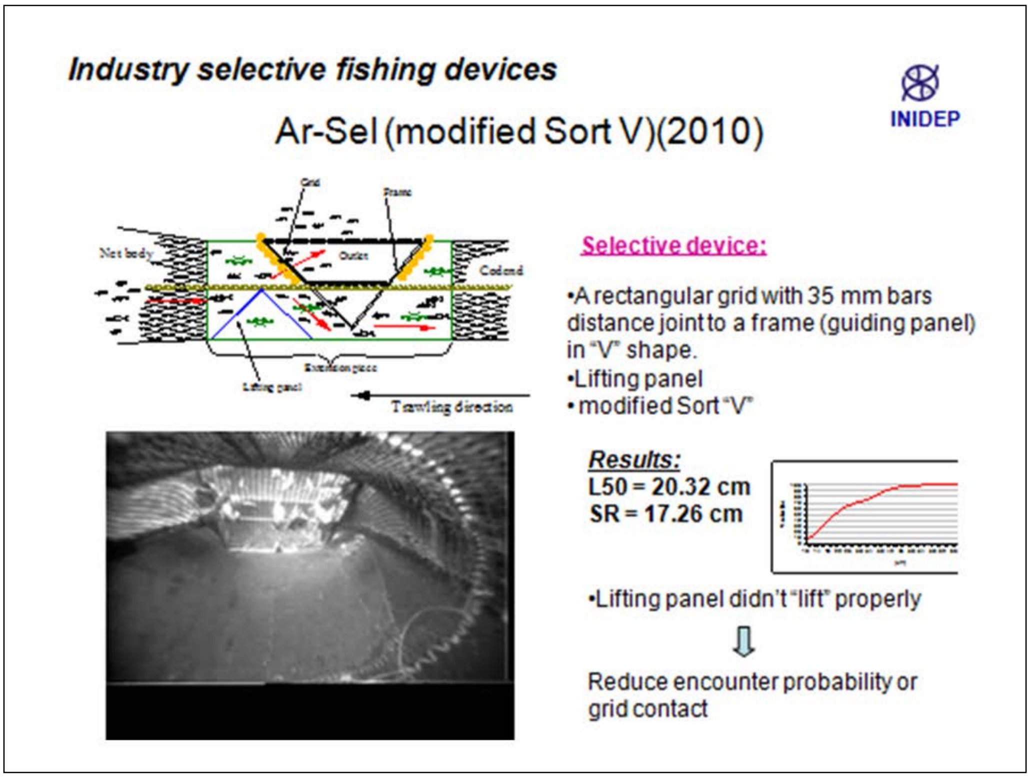
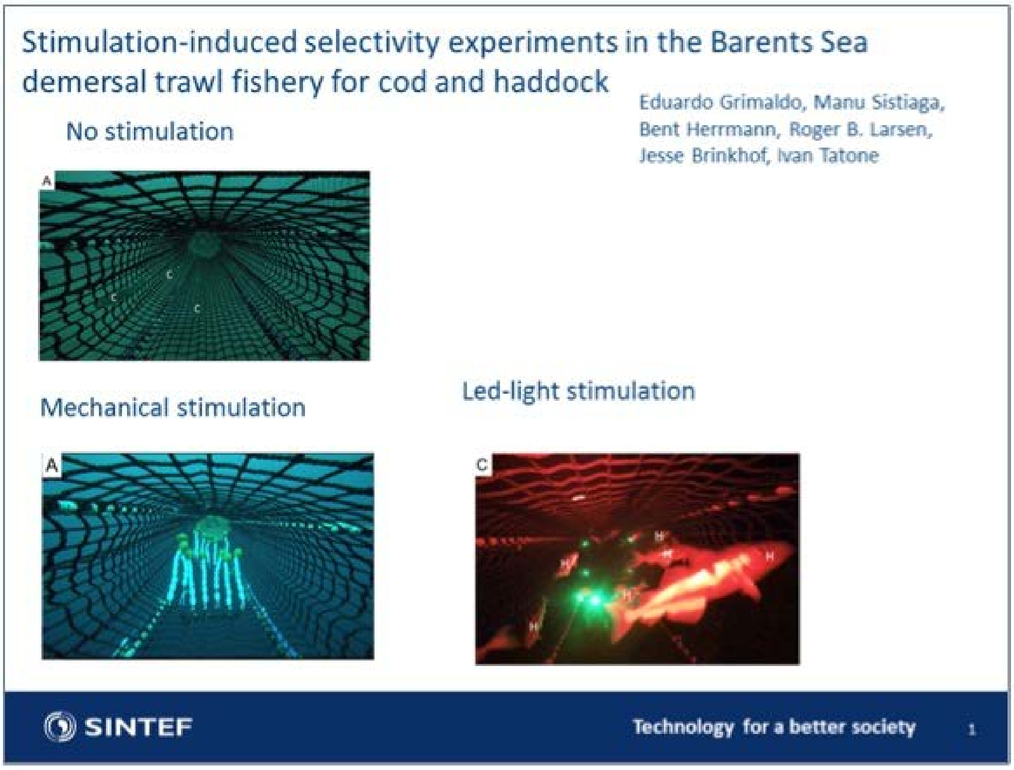


Figure 10.4.6. Summary of presentation, given by Julio Garcia (INIDEP; Argentinia): experiments regarding grid-based selectivity systems

Figure 10.4.7. Summary of presentation, given by Pieke Molenaar (IMARES, Netherlands): selective devices for the Dutch *Nephrops* fishery

Figure 10.4.8. Summary of presentation, given by Pieke Molenaar (IMARES, Netherlands): selective devices fort he Sole and brown shrimp fishery



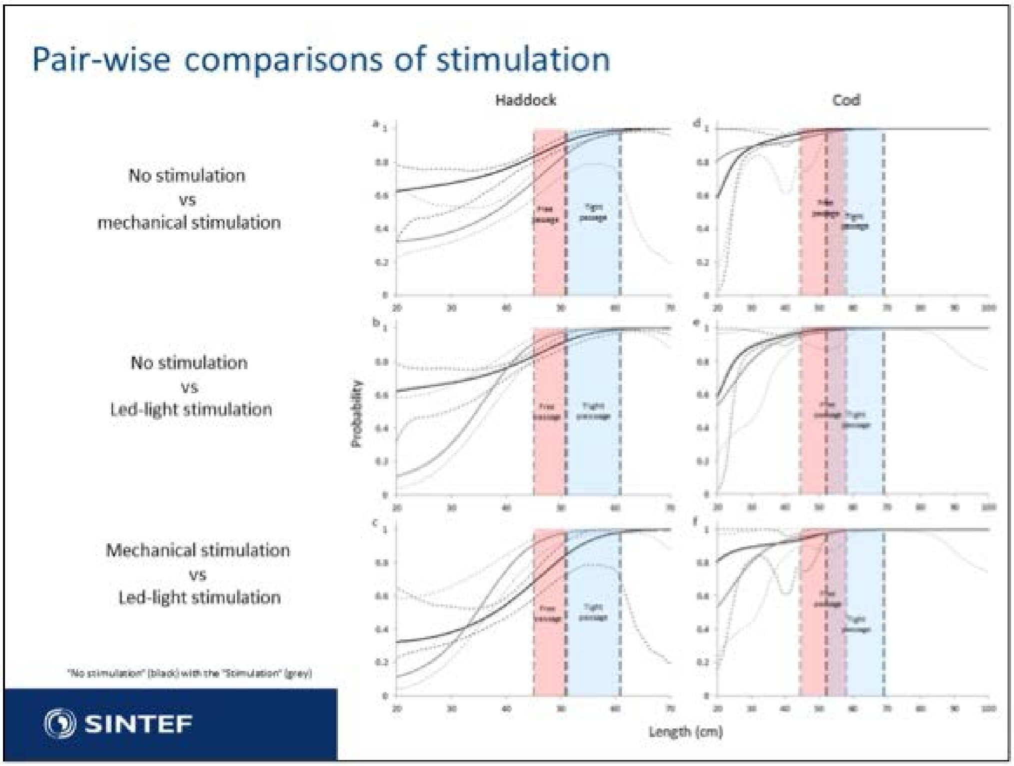


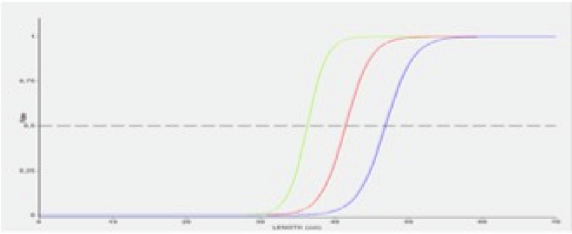
Figure 10.4.9. Summary of presentation, given by Bent Herrmann (SINTEF; Denmark): Stimulation-induced selectivity.

Summary for ToR on Contact Probability

- There are 2 trawl fisheries in the Basque Country with the following operational parameters:

Fishery	Footrope length (m)	Floatline heith (m)	Wingspread (m)	Towing speed (knots)	Codend mesh size (mm)
Single trawl	80-100	1.8-2.4	22-26	4	70 + SMP
Pair Trawl	200	30	100	2	100

- From 2009 to 2012 the mandatory SMP has been tested in the Single trawl fishery. Results for hake show low escapement rate < 4% (Alzorriz *et al.* 2016).
- Since 2015 we have started working to improve selectivity on pair trawl.
- Work started with a fall-through experiment (70-80-90 mm nominal mesh) to identify the most suitable mesh size in relation with MCRS for hake (27 cm).



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Summary for ToR on Contact Probability

- From this experiment 76 mm mesh size has been identified, nevertheless 86 mm mesh size was selected to improve contact probability.
- Several cruises have been performed and some good results achieved on escapement through the SMP for Choke Species.
- Underwater footage reveals that in the pair trawler fishery the gear remains stopped quite long during the hauling back, and is in this moment where part of the hake selection occurs. The fish escaped through the SMP and retained by a cover could also enter again into the gear, resulting in an underestimation of the escapes.
- In addition, in two of the tows SMP was set in the lower panel of the trawl showing the highest escapement rate observed during the cruises. This matches up with the underwater video observations where hake vertical distribution inside the trawl is higher in the lower part of the gear.

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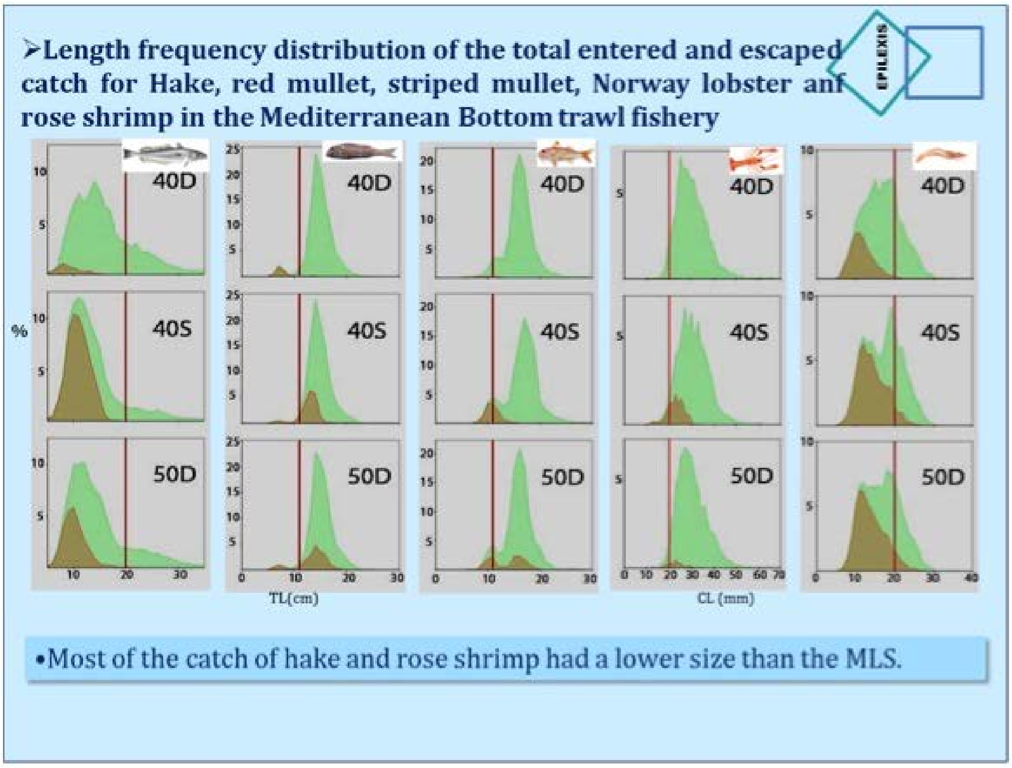
Figure 10.4.10. Summary of presentation, given by Iñigo Onandia and Luis Arregi (AZTI; Spain): Discard reduction experiments on the Basque trawler fleet



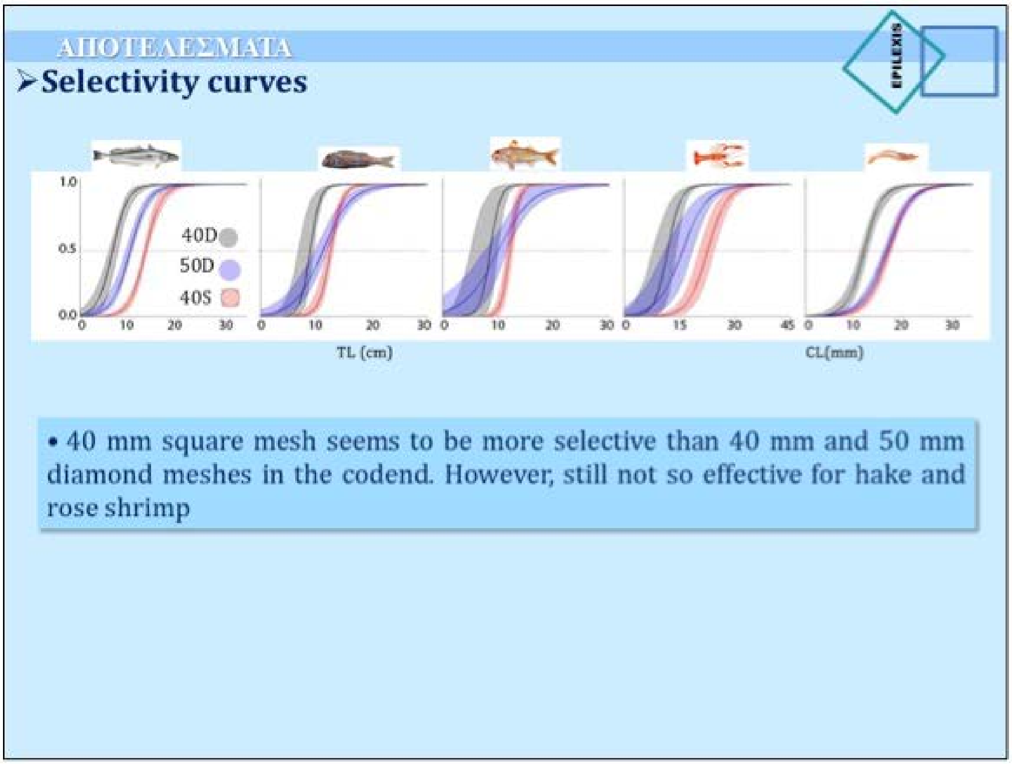
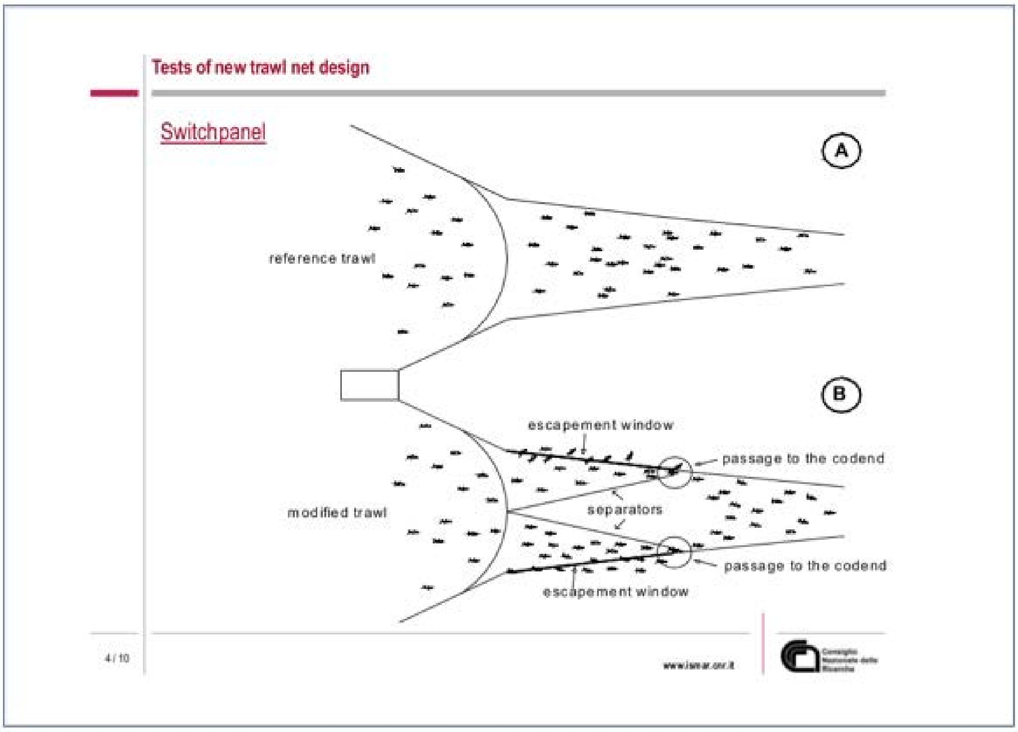


Figure 10.4.11. Summary of presentation, given by Chryssi Mytilineou (HCMR; Greece): Greece selectivity experiments in the Mediterranean Sea



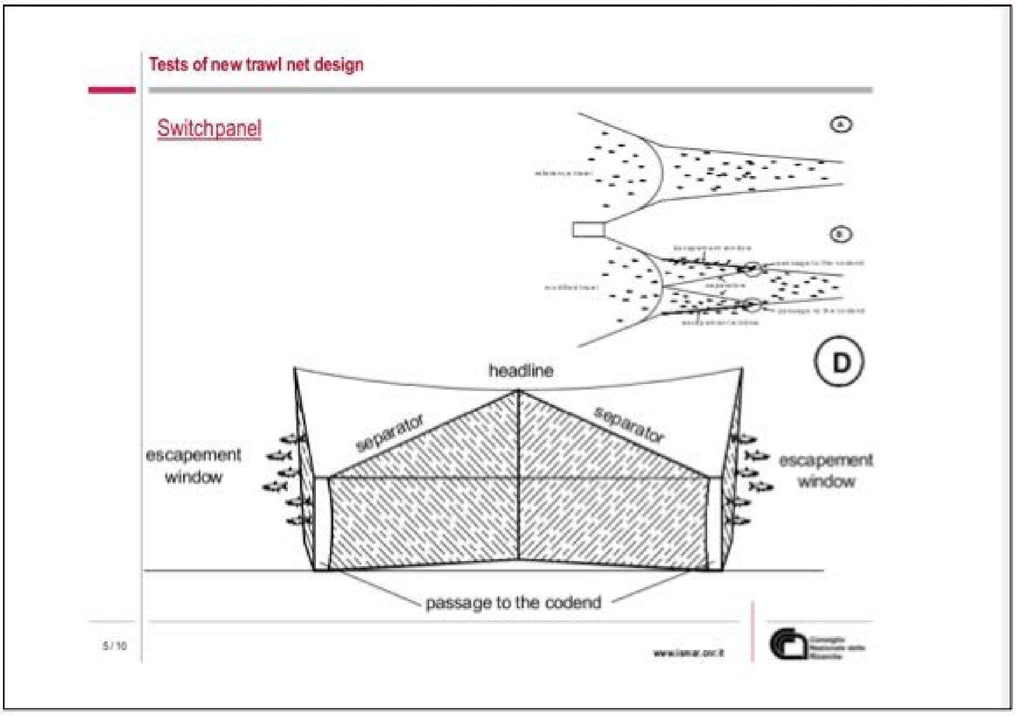


Figure 10.4.12. Summary of presentation, given by Antonello Sala (CNR; Italy): Tests of a new trawlnet design (which guides the fish tot he side panels) – preliminary results of sea trials in the Mediterranean Sea.

11 National Reports

11.1 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 received: Canada, France, Germany, Iceland, Belgium, Italy, Denmark, Netherlands, Norway, Spain, Scotland, Sweden, and the United States. The full text of these reports is inserted below, by country. A summary of some of the major themes across nations was prepared during the meeting. A word cloud was produced from the full text of the National Reports as a means of simply illustrating the main areas of interest in the reporting countries (Figure below). 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 "codend", "discard", "fishing", "fishery", "selectivity" and "catch" were common.

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

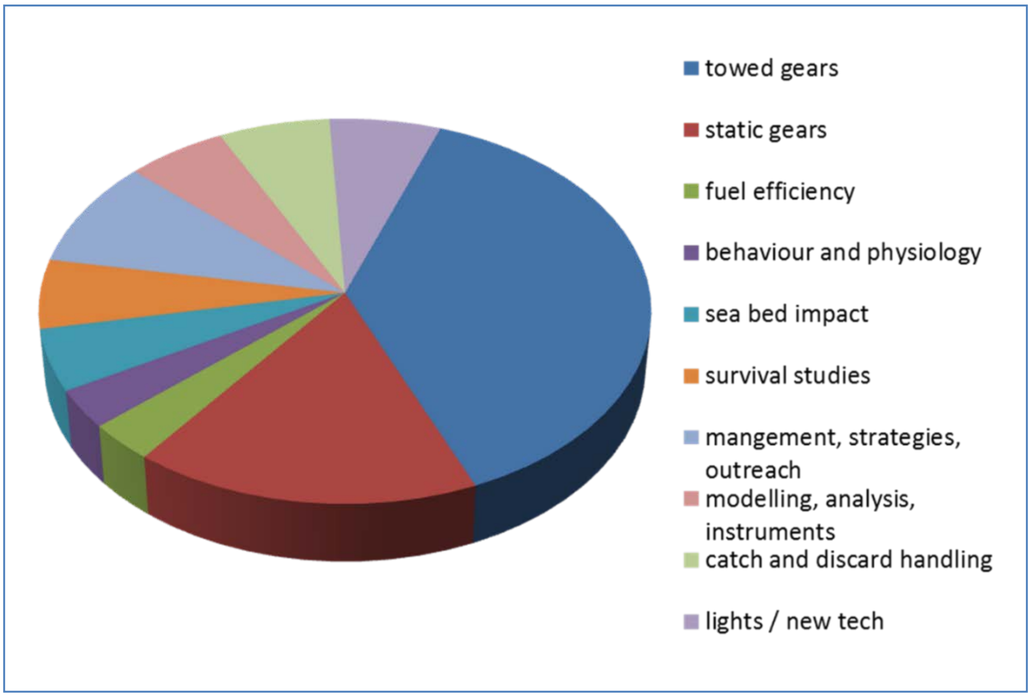
To provide a brief overview of the research being carried out the projects described in the National reports were classified as being related to:

a) towed gears,
b) static gears,
c) fuel efficiency,
d) behaviour and physiology,
e) seabed impact,
f) survival studies,
g) management, fishing strategies, outreach,
h) modelling, analysis, instrument development, and
i) catch and discard handling
j) new technologies.

It is recognized that projects can belong to more than one classification and that the classifications are not necessarily independent. The following figure portrays the proportion of projects in each classification.

Projects related to towed gears predominate (~ 38%), with about half as many static gear projects reported (~ 17%). There were 3–9% of projects related to fuel efficiency;

behaviour and physiology; seabed impact; survival studies; management, fishing strategies and outreach; and modelling, analysis, instrument development, catch and discard handling and new technologies.



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

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**.

11.2 Iceland

Marine Research Institute

Contact: Haraldur Arnar Einarsson (haraldur@hafro.is); Einar Hreinsson (eihreins@hafro.is); Hjalti Karlsson (hjalti@hafro.is).

Selectivity in bottom trawls

In recent years, the selectivity research on bottom trawls has been focused on evaluating the effect of size and design of the trawl body itself on codend selection. It was demonstrated that both trawl design and trawl size had significant effect on the codend selection. As an attempt to reduce this effect (variance) and to improve fish quality, a four-panel codends was set to focus. First trials was done in 2014 with traditional four-panel codend that showed increased L50 in same mesh size and by fishers the quality meant to be improved. The fishing gear producer Hampidjan designed a four panel codend of 155 mm inside mesh size in the T90 formation. This codend design is mounted on (hung on) lengthwise frame lines. Preliminary trials with this new four-panel design were made on a commercial trawler in October 2015, comparing the new design with conventional two panel codend of the same mesh size, using the codend cover method. The results showed that for cod (*Gadus morhua*) L50 = 56 cm, SR = 8,5 cm, CI : ~1cm, in the new T90 four-panel codend, and L50 = 46.9 cm, SR = 11.4 cm, CI: ~ 3cm for the conventional two-panel codend. In addition, the T90 codend retained significantly fewer redfish (*Sebastes marinus*) which might contribute to increased white fish quality.

An increasing number of vessels are now using the T90 four panel codend, and further work is planned down these lines, i.e. investigating physical properties difference on the T90 four panel codend selection, to test different mesh sizes, and to test this codend design on other species like redfish and shrimp. (HAE).

The Inshore shrimp fishery: Testing a modified trawl design (topless) with illuminated footrope against a conventional sorting grid

The inshore shrimp stocks (*Pandalus borealis)* are gradually recovering after almost collapsing ten years ago, and traditional selection issues such as bycatch of juvenile cod, haddock and herring have emerged again. The use of sorting grid (Nordmøre) has been implemented by the authorities but heavily opposed by the fishers. The defiance is based on two main arguments. First, the use of the grid on inshore grounds can cause huge catch losses due to seaweed grid clogging. Second, the grid will not cope with the relatively high catch rates (100–200 kg/min) common in the inner fjord areas. In addition, it is known to both fishers and scientists that excluding juvenile cod, haddock and herring from shrimp of similar body size as the juveniles is not as effective as when dealing with these species 1 year or older. Therefore, the MRI and the vessel owners joined forces in 2014 and initiated a research project with the aim of comparing the sorting grid against a modified trawl design (topless) with illuminated footrope. So far comparing tests have been made in three separate research trips, one in March 2014 and two in 2015, March and November. In these experiments three vessel where used, one rigged with conventional trawl and covered codend. The second vessel was rigged with conventional trawl and a 19 mm sorting grid, and the third vessel was rigged with modified trawl design (topless) and illuminated footrope. The results are still being processed, but already indicating that the modified trawl with footrope illumination could be an alternative to the sorting grid. It was also regarded important to separate the effect of illuminated footrope and the top-less design on fish avoidance. Experiments are now running with the modified trawl design comparing the bycatch volume and composition between light turned on and off. Plans are made to measure selectivity of different shrimp codend types (diamond, square and T90 meshes) at the end of this year. (HK and HAE).

Selectivity in the Nephrops fishery

Bycatch of juvenile fish in the Icelandic *Nephrops* fishery is of constant concern. In April 2015 trials with divided codends similar to what has performed successfully in Denmark where made on a commercial trawler. The upper codend had a mesh size of 135 mm with T90 formation. The lower codend had 90 mm inside mesh and was rigged with a steel frame at the front end. The lower codend retained most of the *Nephrops* but 18% ended in the upper codend and escaped through the T90, 135 mm netting. Cod larger than 55 cm was more likely to enter the upper codend and saithe larger than 75 cm as well. Witch flounder smaller than 43 cm was more likely to end up in the upper codend, but larger flounder was equally divided into both. Some practical disadvantages of the Danish setup emerged during the trials. The two codends tended to twist during hauling, and the steel frame caused some danger to the deckhands. A plan for further trials with a new version is scheduled later this year. (HAE).

One short survey was conducted on a commercial trawler last November (2014) where four-panel codend with 135 mm mesh was tested with cover. Two method of mounting the four-panel codend to two-panel trawl was tested. Three species was measured; cod, haddock and redfish. There was no significant difference between the methods of mounting the codend on the trawl. Cod was measured near 40 cm in L50, haddock just under 44 cm but redfish was surprisingly high in L50 or 40.5 cm (~ 1 kg). Further investigations are planned but not on this year's schedule. (HAE)

11.3 Germany

Thünen–Institute for Baltic Sea fisheries

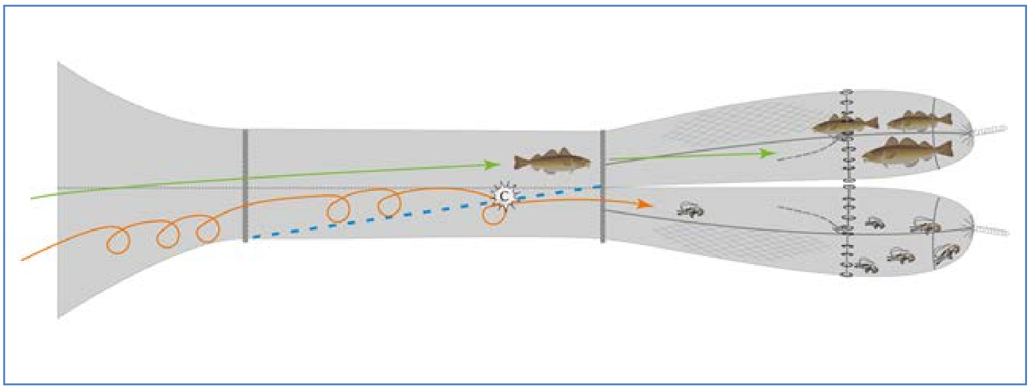
Working group on fisheries and survey technology

Contact: Daniel Stepputtis (daniel.stepputtis@thuenen.de) (notice new e-mail-address). Website: https://www.thuenen.de/en/of/fields-of-activity/research/fisheries-and-survey-technology/

HESPAN, An alternative approach for species selection in Nephrops fisheries (Cruise SO709 with FRV "Solea"; 09/2015)

Contact person: Juan Santos (juan.santos@thuenen.de), Bernd Mieske (bernd.mieske@thuenen.de)

High bycatch rates are usually associated to *Nephrops* fisheries, caused by the small mesh used in commercial codends. Devices such as square mesh panels (SMPs) and grids have been implemented to supplement codend selectivity, but the low success achieved in some of these fisheries, indicates that new perspectives for alternative solutions are required. HESPAN is a new concept for selection device specially developed for *Nephrops* fisheries. The new concept consists of a long SMP inserted obliquely in the extension of the trawl. The oblique panel is mounted with a smooth bottom–up angle, intended to guide fish species to an upper codend, while sieving *Nephrops* to a lower codend regardless of individual size. HESPAN has been developed and tested in Skagerrak Sea during September 2015. The structural model applied in data analysis estimated more than 85% of Nephrops efficiently contacted HESPAN, but the sieving to the lower codend was unexpectedly dependent on *Nephrops* length size. Underwater video recordings collected during the sea trials showed *Nephrops* hitting & rolling over the panel, but also active interactions such as attempts to burying in the square meshes or holding the twines with the claws. Additional investigations are required to improve the performance of the current HESPAN design. This work is presented as poster during WGFTFB 2016.

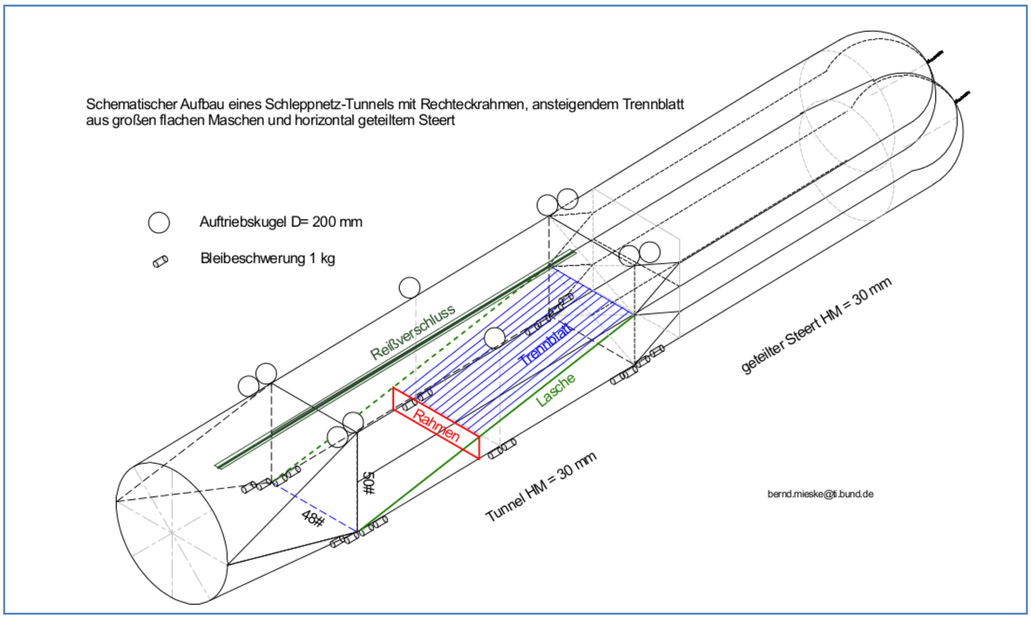


Schematic overview of HESPAN selection device (side view).

SORTEX, a new system to split flatfish and roundfish in demersal trawl catches. (Cruise SO718 with FRV "Solea"; 03/2016)

Contact person: Juan Santos (juan.santos@thuenen.de), Bernd Mieske (bernd.mieske@thuenen.de)

The knowledge acquired in recent times on the behaviour of flatfish and roundfish species during the catch process, has been used in the development of a new trawl gear, which aims to sort these group of species into different codends with adapted selectivity (see national report WGFTFB 2015 and presentations at WGFTFB 2016). SORTEX (SORTing EXtension) is based on the HESPAN concept (see previous entry); it consists of a net panel made of large meshes in T90 orientation, which is mounted obliquely in the extension of the trawl. The oblique panel split the aft of the trawl in two longitudinal spaces - lower and upper- , ending in two separated codends (upper and bottom codend). The forward edge of the oblique panel is mounted to a rigid square frame with 20 cm height, leaving a free passage for flatfish to the lower codend. Roundfish species should be driven by the bottom–up inclination of the panel towards the upper codend, while flatfish might enter in the lower codend by i) passing through the rigid frame surface, or ii) passing through the T90 meshes of the oblique panel towards the lower codend. SORTEX was tested for first time during the research cruise SO718 (03/2016). A total of five different setups were tested. Setups varied in the angle the panel was mounted in the gear, and different deterrent systems to prevent roundfish entering in the lower codend. In the best setup tested, 85% of the total cod catches (numbers) were observed in the upper codend, while 92% of total plaice catches (numbers) were observed in the lower codend. An efficient SORTEX performance will allow the use of selective codends specifically adapted for roundfish and flatfish species. This would provide fishers with flexibility to quickly alter their exploitation patterns in response to rapid changes in management demands (in particular considering potential problems with choke species).

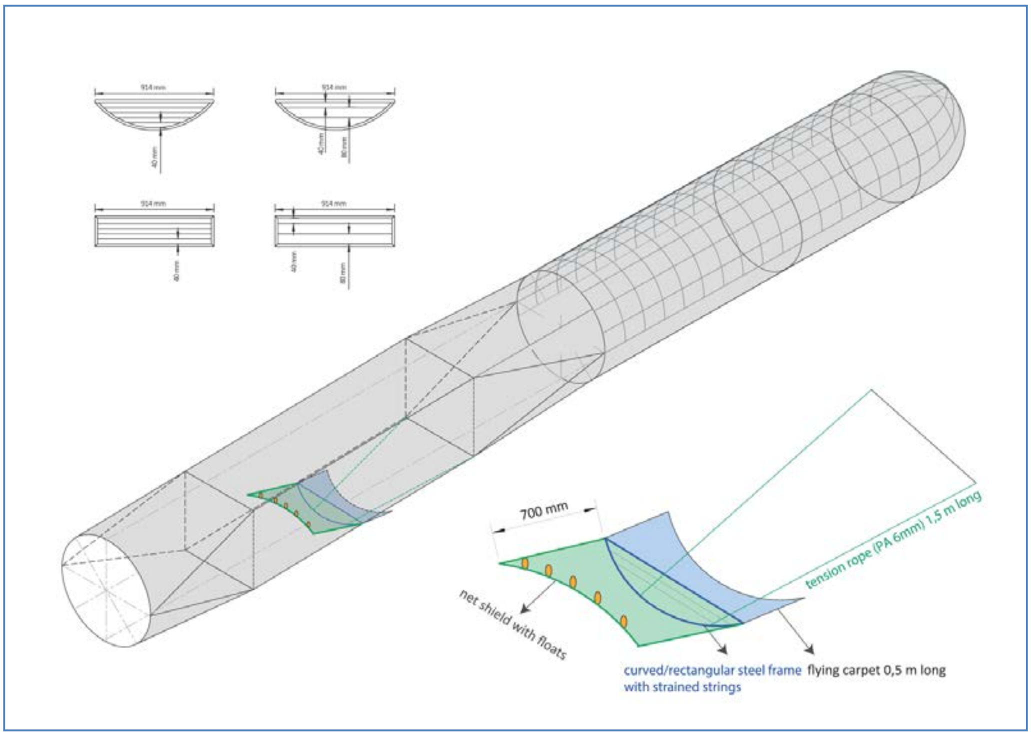


Schematic overview of SORTEX selection device

Development and testing of FLEX, a simple BRD to reduce the bycatch flatfish (cruise: SO711; 09/2015)

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

In the Baltic trawl fishery for cod, flatfish are often caught as unwanted bycatch and finally discarded back to the sea. To reduce the flatfish bycatch, some escape devices have been developed and tested in the Thünen Institute so far. The best results were achieved with the - so-called FLEX escape device (several designs were tested). With FLEX; flounder catches were reduced by 82% and plaice by 57%, compared to a conventional trawl without a selection device. A disadvantage, however, is the potential loss of cod of up to 18% of the captured numbers (depending of the tested design). The aim of this sea trial was to improve the flatfish selection device FLEX so that the escape of cod can be reduced. In the escape opening, differently shaped rigid frames were inserted. In these frames strained strings were mounted, in order to aggravate the escape of cod. Furthermore, the original 20 cm long net shield at the top of the escape opening was extended by 50 cm in all new versions. The best results were achieved with a rectangular frame in the FLEX- opening, in which the spacing of the blocking threads was 8 cm. Thus the flounder catch was reduced by 90% and the plaice bycatch by 89 %. However, the cod catch was not reduced compared with a trawl without an exit device. The different versions of FLEX could be adapted to other roundfish fisheries. This work is presented as oral presentation during WGFTFB 2016.



The FLEX-extension with different shaped steel frames and different thread spacings inserted in the escape opening.

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

Contact person: Overall project leader: Gerd Kraus (gerd.kraus@thuenen.de); Selectivity: Juan Santos (juan.santos@thuenen.de); Daniel Stepputtis (daniel.stepputtis@thuenen.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.

Therefore, a project was conducted to improve the size selectivity of codends in this fishery to give advice on technological improvements towards sustainable exploitation patterns. In contrast to previous research projects, the project 'CRANNET' not only determined the size selectivity of a wide range of codend designs (36 codend designs; netting orientation: T0, T45, T90; mesh size: range between 15 mm and 36 mm). Moreover, the optimal codend designs were identified based on the influence of selectivity on population dynamics and resulting commercial catches of the fishery, using population and economic models. The models presented in this study can be used as predictive tools to simultaneously adapt the mesh orientation and mesh size of commercial codends to meet specific necessities of the fishery. In addition, the influence of size selectivity, and timing of introduction of new codends on population dynamics and commercial catches were investigated. The project was finalized in 2015 and the report (in German) can be found at:

https://www.ti.bund.de/media/institute/sf/Projektdateien/468/CRANNET_Abschlussbericht.pdf

11.4 Canada

Fisheries and Marine Institute

Memorial University of Newfoundland, St. John's, NL

Emerging fishery – Porcupine crab

We have now completed a two-year field experiment (2014 and 2015) on board a 30.5 m commercial gillnet fishing vessel (*FV Arluk II*) in NAFO Division 0B. The primary focus was to collect information on the Porcupine Crab (*Neolithodes grimaldii*), a species commonly captured incidentally in Turbot gillnet fisheries in Atlantic Canada. The objectives of the study include 1) development of fishing gear that targets Porcupine Crab, 2) examine factors influencing bycatch of Porcupine Crab in the Turbot gillnet fishery, 3) assess key biological features of Porcupine Crab, 4) assess health status, shell condition, rhizocephalan parasitic infestation, and post-capture survival of Porcupine Crab, and 5) investigate the stomach contents and feeding behaviour of wild and captive Porcupine Crab. Contact Scott Grant (Scott.Grant@mi.mun.ca).

Invasive green crab – Optimizing capture efficiency

European green crab (*Carcinus maenas*) is a notorious invader on the east and west coasts of Canada, and was discovered in Newfoundland waters in 2007. This two-year study (2015–2016) is using stationary underwater video cameras attached to Fukui traps to study parameters critical to informing the design of an optimal removal program, including rate of crab accumulation in traps, length of time to saturation, the mechanism of saturation, and whether there are differences in these parameters across distinct populations. These findings will inform the optimization of soak times, and will identify whether bottlenecks exist in the capture process that could be addressed with modifications to the trap design. In addition, we propose to employ underwater filming to examine how a green crab invasion affects the performance of lobster and eel traps, two fisheries that occur within the invaded sites. Contact Brett Favaro (Brett.Favaro@mi.mun.ca).

LED lights – shrimp trawls and crab pots

In partnership with Hampidjan Canada Ltd. and Fisheries and Oceans Canada, this project is investigating the potential benefits of adding small low-powered LED lights (Lindgren-Pitman) to fishing gears. Laboratory experiments have been completed to investigate the behaviour of snow crab toward various colours. Field experiments are currently underway. Two particular applications are being pursued: 1) reducing by-catch of capelin and juvenile redfish in shrimp trawls, and 2) improving the catch efficiency of snow crab traps. Initial sea trials were conducted in 2015. Additional sea trials are planned for 2016. Contact Paul Winger (Paul.Winger@mi.mun.ca).

Improving baited cod pots

A two-year study is currently underway in partnership with harvesters in Fogo Island, Newfoundland to improve baited pots for Atlantic cod. Last year (Year 1) we investigated the catching performance of the Norwegian and Newfoundland cod pot designs, in side-by-side comparative fishing experiments. Underwater video was also collected to understand barriers to increasing catch rates. Why do so few successfully enter? This summer (2016) we hope to test a new and improved cod pot design that incorporates the benefits of both the Norwegian and Newfoundland designs. Contact: Philip Walsh (Philip.Walsh@mi.mun.ca).

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

Controlling bait costs in the American Lobster and snow crab fisheries in Quebec

For Québec trap (pot) fisheries, bait represents significant costs. It could reach up to 15% of the daily revenues. Another challenge: populations of wild-caught finfish (Atlantic mackerel and herring) in the Gulf of St-Lawrence (NAFO 4RST), used traditionally as baits, are less available thus becoming too expensive. We test options like the use of artificial light or alternative attractants, which diffuse a similar mixture of molecules like the ones previously isolated in some wild-caught fish. Finally, Merinov is assessing the potential of using grey seal by-products to reduce dependence on finfish. 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 was related only to the installation and the optimization of the kite system onboard. Launching and recovering operations and security tests was performed. Some kite traction has been tested, but these prototype need to be improved to be easier to handle and to deploy from the boat. A second step, giving a new sail a trial will be necessary for the system to be upgraded. 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).

Smart gear: gillnet fishing bycatch reduction

In Quebec, gillnet fishing gear of monofilament kind is used for the commercial fishing of Greenland halibut (*Reinhardtius hippoglossoides*), and is directly related to the problem of incidental bycatch of marine species, including some listed in Annex I of SARA. The project aims to reduce bycatch occurring within monofilament gillnets. The specific objectives of the project are (1) to produce a comprehensive literature review on bycatch mitigation technologies that have been developed regionally, nationally and internationally; and to manage assessment questionnaires to fishers in order to evaluate the average number of catches before technological experimentation; (2) to select a technological innovation to experiment on the gillnet and finally, (3) to evaluate the impact of technological innovation on the number and species affected by bycatch. The methodology for the collection and analysis of results will be mixed including qualitative methods (questionnaire and semi-structured interviews) and quantitative methods (experimental research, statistics). Contact Stéphanie Pieddesaux (Stephanie.Pieddesaux@merinov.ca)

PDG 2: Reducing impact of scallop dredges on seabed

The aim of this study was to respond to a request from Magdalen Island scallop's fishers. This need was expressed during a 2010 workshop with scallop's fishers and scientists from Quebec, United States and France, The main objective was to observe the scallops swimming behaviour escaping off a Digby dredge, as well as gear dragging on the rocky seabed. During spring and summer 2014 we did approximately six fishing trips with two scallop's fishers. A HD trawl cam was attached on the bridle just in front of the dredge and a GO PRO cam was fixed directly on the dredge. A movie with the best images was presented to the fishers in winter 2016 to get their feedback. Contact Lisandre Solomon (lisandre.solomon@merinov.ca).

Development of a multi-level trawl for the study of bycatch and northern shrimp vertical distribution for the optimization of the shrimp trawl in Quebec's fleet

The main objective of this project is to develop a multi-level trawl in order to collect data on the vertical distribution of problematic bycatch species and northern shrimp in the commercial trawl. The study includes three steps: 1) the conception of a multi-level trawl subdivided in three vertical sections; 2) the sea trials (adjustments of the device and sampling methodology); 3) the realization of a conciliation workshop with the industry. The results obtained will ensure the success of a second phase for large-scale sampling, and to further develop an innovative commercial trawl (phase 3), aiming to reduce the vertical opening and develop exclusion devices for bycatch. This project will be profitable both in scientific (fish and shrimp vertical distribution data) and economic terms. Ultimately, the profitability and competitiveness of the industry will be increased (fuel savings, reduction of bycatch and seabed impacts). In 2016, simulations using the DynamiT software from Ifremer have been completed, and the multilevel trawl construction is expected in May 2016, with the first sea trials this summer. Contact Marie-Claude Côté-Laurin (marie-claude.cote-laurin@merinov.ca)

Experimental fishery of Sculptured shrimp (Sclerocrangon boreas): feasability assessment of this new fishery

Fisheries diversification is one of the main challenges of the Gulf of Saint-Lawrence North Shore and developing new fisheries is a key factor. The goal of this project is to assess if harvesting the sculptured shrimp might be economically feasible regarding to available biomass, fishing technology and environmental conditions. The first step of the project has been completed in 2014 and allowed to describe the spatial distribution, the available biomass as well as biometrics of the population sampled in this area. The second step of the project (currently in progress) aimed to design efficient traps for this species. Afterwards, they are will be comparative efficiency and selectivity at-sea tests in experimental as well as commercial conditions. Contact Marie Lionard (marie.lionard@merinov.ca)

Safety design criteria of working stations like pots hauler and supporting rack onboard lobster boats in Quebec LFA

Since 2012, an important research program concerning lobster boat crew safety was undertaken in the Quebec Gaspe Peninsula and Magdalen Islands fisheries. In cooperation with Laval University ergonomists, as for the first stage, we analyse the risks of and determine factors involve in overboard falls; we document collective and individual prevention solutions that can be adapted to lobster boats; and we identify, with lobstermen, the most promising risk reduction scenarios. In 2015, in a second stage, we developed, tested at-sea and implement practical integrated technical solutions about the pots hauler and the supporting fishing lines rack. Both are the devices most used by crewmen for easing their work. Attention has been paid to reduce ropes entanglement risks and body efforts when hauling and launching the fishing gear. Results are currently under analysis.

Useful references:

Overboard Falls of Crew Members on Québec Lobster Boats. Risk Analysis and Prevention Solutions. Sylvie Montreuil, Francis Coulombe, Jean-Guy Richard and Michel Tremblay. 2015. IRSST/R-869.pdf. 67p+ appendices 34 p. http://www.irsst.qc.ca/media/documents/PubIRSST/R-869.pdf

Setting the Course for Safety: Preventing Falls Overboard. Video.

http://www.irsst.qc.ca/en/headlines/id/322/lobster-fishing-preventing-falls-overboard

Contact: Francis Coulombe (francis.coulombe@merinov.ca)

11.5 The United States of America

Massachusetts Division of Marine Fisheries

Conservation Engineering Program, New Bedford, MA

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

ExpandedWhiting: Revision of Existing Whiting Special Access Areas

Special access areas face obsolescence due to temporal and spatial changes in distributions and abundances of fish populations. We are developing an experimental fishery and research plan to collect data from commercial vessels to investigate possible alteration of timing of whiting (*Merluccius bilinearis*) small mesh (64–76 mm) areas in response to fishers's requests. This effort will likely be multiyear. So far, observer data were obtained and analysed for catch and bycatch trends.

ScanPot: Development of sidescan sonar methodology to survey derelict lobster pots in sandy and rocky habitats in Massachusetts

This project demonstrates the efficiency of sidescan sonar to find derelict "ghost" lobster (*Homarus americanus)* pots in rocky habitat. An area with diverse bottom types was surveyed, and then seeded with a randomized number of pots. An operator naïve to the number set then identified possible pots based on sonar signature in the field, and will also review all scans in the laboratory. Detection rates (number of pots found with sonar/number of pots set) in varying habitats will be calculated, and then used in a pilot survey to estimate counts of derelict pots. If effective, this technique could be a cornerstone of a region-wide detection and removal effort.

TickleDredge: Bycatch reduction of the sea scallop fishery

In collaboration with Provincetown Center for Coastal Studies (O. Nichols), we will test a simple modification to the New Bedford-style scallop (*Plactopecten magellanicus*) dredge to reduce flatfish bycatch by suspending drop chains from the bail. The intent is to disturb flatfish that are on the bottom, causing them to swim up and away from the approaching cutting bar and preventing capture in the dredge. Video and fieldwork are planned during summer 2016.

ULOT: Developing an ultra-low-opening groundfish trawl to avoid cod and ensure a prosperous inshore fishing fleet

A collaboration with Steve Eayrs of Gulf of Maine Research Institute, Pingguo He of SMAST, and several industry members, to develop a trawl with a very low headline height, with the idea of fishing under cod for flatfish. Fieldwork planned for May 2016. More information below at GMRI.

A modified sort-x grid to reduce the catch of juvenile haddock and cod in the Georges Bank haddock fishery

In partnership with Pingguo He, a project to design and test a "dual-grid" system for eliminating small haddock from a trawlnet before they reach the codend, as a means of protecting small haddock. The concept is based on the premises that 1) codend escapees on the bottom suffer some mortality due to fatigue and squeezing through meshes and 2) a substantial amount of escape occurs during haulback and at the surface; these escapees are subject to additional potential sources of mortality (sun exposure, seabirds, pelagic predators) beyond injury and fatigue from escape. See more below.

REDNET: A network to redevelop a sustainable redfish (Sebastes fasciatus) trawl fishery in the Gulf of Maine

Data analysis and report writing continue. Analysis cantered on determining the effectiveness of a dual-grid (modified Sort-X) system to improve size selectivity for Acadian redfish. Results indicated that the grid systems were effective at reducing small fish, and that an optimum size for the fishery would be in-between the two grid spacings tested (40 and 50 mm). Analysis of escape location from codends using video is underway. Results will be used to make recommendations for the fishery.

University of Massachusetts Dartmouth

School for Marine Science and Technology (SMAST), Department of Fisheries Oceanography, New Bedford, MA

Fisheries Biology and Assessment Lab

Estimating and mitigating discard mortality in the Gulf of Maine recreational groundfish fishery

John Mandelman (jmandelman@neaq.org), Connor Capizzano, and Emily Jones (New England Aquarium), Douglas Zemeckis, Crista Bank, and Steven X. Cadrin (University of Massachusetts Dartmouth), William Hoffman, Micah Dean, and Matt Ayer (Massachusetts Division of Marine Fisheries, Hugues Benoît (Department of Fisheries and Oceans Canada)

Removals by the recreational fishery can represent a considerable portion of the total annual removals for some Gulf of Maine groundfish. However, the lack of directed discard mortality studies for the Gulf of Maine recreational groundfish fishery leaves uncertainty in total fishing mortality estimates, which complicates fishery management decisions. The capture-related factors most detrimental to Atlantic cod (*Gadus morhua*) discard mortality were examined for the recreational rod-and-reel fishery using a combination of acoustic telemetry and conditional reasoning. Mean tackle-specific discard mortality rates of 15.4% and 21.2% were estimated for bait- and jig-captured cod, respectively, with an overall 16.5% mean discard mortality rate for the 2013 Gulf of Maine recreational cod fishery. The majority (~ 90%) of deaths occurred within 16 hours post-capture. Upon evaluation with a specifically adapted parametric survival analysis, greater incidence of mortality was attributed to the capture and handling process (rather than release) for moderately- and severely-injured cod. Based on the capture-related factors associated with the highest injury rates, we recommend minimizing fight and handling times, avoiding areas with small cod, educating inexperienced anglers, and favouring bait over jigs in order to mitigate mortality. Ongoing research is being conducted in collaboration with the recreational fishing industry to apply a similar approach to estimate the discard mortality rate of haddock (*Melanogrammus aeglefinus*) captured with rod-and-reel fishing gear. Both studies on cod and haddock are timely for consideration in the management of the Gulf of Maine recreational groundfish fishery, because of recent increases in recreational discards due to increased recreational fishing effort, strict regulations, and species' relative abundances in recent years. Another groundfish targeted by recreational anglers is cusk (i.e. tusk: *Brosme brosme*), which is listed as a Species of Concern in US waters. Due to the regulatory measures imposed on cod and haddock, cusk may soon see an increase in fishing pressure because there are currently no management measures for them. Since cusk discard mortality is believed to be high due to their susceptibility to barotrauma, we are working to estimate cusk discard mortality and test the efficacy of release devices for increasing the survival of discards. Results from all three studies can assist with future fishery management decisions and reduce incidental mortality of these discarded groundfish.

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Fish Behavior and Conservation Engineering

Pingguo He (phe@umassd.edu)

Testing of a topless shrimp trawl for brown and pink shrimp in the North Carolina's Pamlico Sound shrimp fishery

This project is carried out in collaboration with North Carolina Division of Marine Fisheries (Kevin Brown) to test a topless shrimp trawl for the Pamlico Sound fishery that target brown shrimp (*Farfantepenaeus aztecus*) to reduce finfish bycatch. Both the commercial trawl and the experimental topless trawl were tested in full-scale in the flume tank at the Fisheries and Marine Institute in Newfoundland Canada. Sea trials were carried out in summer 2015. The primary bycatch species were Atlantic croaker (*Micropogonias undulatus*) and spot (*Leiostomus xanthurus*), which accounted for 35.5% and 18.8% of the total catch, and 57.1% and 30.5% of the total bycatch, respectively. Based on the preliminary analysis of data from sea trials, the experimental topless trawl reduced the overall bycatch by 22.9% compared to the standard shrimp trawl. The catch rate of Atlantic croaker was reduced by 17.1% and the catch rate of spot was reduced by 28.4%. However, there was a 34.5% loss in the target species, brown shrimp, indicating that the topless design might not be suitable for the brown shrimp fishery in the Sound.

Semi-pelagic trawling for haddock to reduce flounders

This project was in collaboration with Massachusetts Division of Marine Fisheries (Kike Pol) to test a semi-pelagic rigging of a typical groundfish trawl to target haddock on Georges Bank with the aim to reduce yellowtail flounder (*Limanda ferruginea*) and windowpane flounder (*Scophthalmus aquosus*). The experiment rigging used a set of pelagic trawl doors fishing with doors off bottom, while the commercial rigging use a set of bottom doors fishing with doors on bottom. A floating sweep was used in the experimental rigging. Fuel consumption was also monitored and compared between two rigs. Sea trials for this project were completed in April 2015. The preliminary data showed a significant reduction in bycatch, including reductions in all major flounder species. Additionally, the semi-pelagic trawl also showed a 17.2% reduction in fuel consumption compared to a standard commercial trawl. A significant reduction in haddock was documented, however, further analysis into the size distribution of the catch may yield additional insight into this issue.

A modified Sort-X grid to reduce the catch of juvenile haddock and cod in the Georges Bank haddock fishery

This new project was in collaboration with Massachusetts Division of Marine Fisheries (Mike Pol) to test a modified Sort-X grid to reduce undersized haddock to help the long-term sustainability of the haddock fishery. Recent research trips revealed that a large portion of haddock brought to the deck of the vessel was below the minimum landing size when the 165 mm legal size codend was used. Many fish escaped while the codend was on the surface due to slacks and swells. These surface escapees are likely to suffer greater mortality than those escaped while the net is still on the seabed. Reduction in juvenile haddock will reduce waste of resources, and unaccounted fishing mortality, leading to healthier stocks and robust fisheries resources. Sea trials will start in the coming spring.

Reducing yellowtail and windowpane flounder bycatch: application of a modified European grid system in the Georges Bank haddock fishery

The fishing industry's full utilization and the maximal benefit of the healthy haddock fishery on Georges Bank (US) rely on the protection of other "choke" species. Recent regulatory restrictions on the Northeast groundfish fishery made it impossible to fully utilize allocations of the robust haddock stock, resulting in 50 to 100 million dollars in foregone revenue. Yellowtail flounder (*Limanda ferruginea*) and windowpane flounder (*Scophthalmus aquosus*) are two of the most severe "choke" species on Georges Bank that impact the successful harvesting of haddock. Reducing these species is thus critical for the fishery that has been plagued by overfishing and stock depletion. The goal of the proposed project is to adapt the successful German flatfish-excluding grid system (FRESWIND) to the Georges Bank haddock fishery to reduce the catch of yellowtail and windowpane flounder while retaining the catch of legal size haddock. The grid system, constructed of horizontal rigid steel bars, exploits morphological differences and swimming behaviour between flatfish and roundfish. The new grid system will reduce the catch of vulnerable flatfish species in the haddock fishery and will improve the survival of the escaped fish. The project will include gear design, underwater observations of fish, and comparative fishing trials on board a commercial groundfish trawler captained by the industry partner. Sea trials will start in spring 2016.

Gulf of Maine Research Institute

Portland, Maine

Steve Eayrs (steve@gmri.org)

Commercial fishing vessel electronic trip reporting pilot study

Contact: Steve Eayrs, Adam Baukus, Aaron Whitman

The goal of this project is to facilitate the use of electronic logbook software by New England groundfish fishers and their transmission of electronic vessel trip reports (eVTRs). The scope of work includes i) working with software providers, sector managers, and NMFS staff to identify and overcome outstanding challenges and limitations to effective transmission of VTR data, and ii) facilitating the use of electronic logbook software by New England groundfish fishers. We have now equipped 41 groundfish vessels (up from 37 last year) with the new eVTR software, although only 22 are currently reporting electronically. These vessels have together transmitted over 1500 trip reports over the past year fishing year. All vessels are using the FLDRS software. We have also recently started to focus on vessels that do not have groundfish as their major target species. These vessels are still required to submit vessel trip reports and may not be overwhelmed with changes to the groundfish industry while being more receptive to a change in reporting. This project is funded by the National Marine Fisheries Service.

The development of an ultra-low-opening groundfish trawl: A solution to avoid cod and ensure a prosperous inshore fishing fleet?

Contact: Steve Eayrs – GMRI; Mike Pol – MA DMF; Pingguo He – SMAST; Chris Glass – UNH; Jon Knight – Superior Trawl; Jim Ford – F/V Lisa Ann III; Tom Testaverde – F/V Midnight Sun; Dan Murphy – F/V Danny Boy; Carl Bouchard – retired fisher

In this highly collaborative effort, we have designed an ultra-low opening groundfish trawl (ULOT) to land flatfish and avoid cod. This initiative is in response to the collapse of the Gulf of Maine stock of Atlantic cod. Subsequently, deliberate fishing for cod has now all but ceased, and the cod quota is so low that it restrains ('chokes') the ability of fishers to land abundant species such as yellowtail flounder (*Limanda ferruginea*), American plaice (*Hippoglossoides platessoides*), and witch flounder (*Glyptocephalus cynoglossus*). We designed the ULOT with a target vertical opening of less than 1 m in mind, a reduction of at least 50% compared to contemporary trawl designs for flatfish. Several designs were considered by project partners before one was selected for numerical modelling at the Centre of Sustainable Aquatic Resources (CSAR) at the Fisheries and Marine Institute, Memorial University of Newfoundland, Canada. Following review of modelling data, a model of the ULOT was tested in the CSAR flume tank. The performance of the ULOT in the tank was satisfactory, following multiple rigging modifications, and a vertical opening of less than 1 m was achieved. Several other trawl designs to avoid cod were also tested at the tank, including a topless trawl with trawl-mouth inserts and rope barriers. Full-scale testing of the ULOT is planned for May/June this year.

Maine Inshore Acoustic Survey for Northern Shrimp

Contact: Graham Sherwood, Adam Baukus

This industry based collaborative effort leverages an existing framework of acoustic technology and survey experience to examine distribution and abundance patterns of Northern shrimp, *Pandalus borealis*, in winter when shrimp migrate to inshore waters. The commercial fishery for the species is facing its third consecutive year of moratorium and the lack of landings data leaves many unanswered questions about effects of fishing pressure, changing water temperatures, and other factors on the population. This survey incorporates ten lobster vessels performing forty-mile survey transects from ports along the coast of Maine, and an additional trawling vessel for sample verification. Shrimp present a challenge for acoustic targeting as their smaller size results in an acoustic signal that could be confused with other small crustaceans, juvenile fish etc. In response to this challenge we are extensively sampling with shrimp traps and miniature shrimp trawls concurrently with the acoustic surveys to verify the acoustic signal from shrimp and other species. We are also collaborating with the federal shrimp survey that operates in summer. An identical acoustic transducer has been mounted in the NOAA vessel and acoustic data will be collected and compared to the entire trawl survey effort. This is a two-year project with year one field operations concluding in April.

NOAA Fisheries Southeast Fisheries Science Center

Harvesting Systems Unit, Pascagoula, Mississippi, USA

Sea Turtle Bycatch Mitigation in the Southeastern US Skimmer Trawl Fishery

Contact: Jeff Gearhart (Jeff.Gearhart@noaa.gov)

Between May and July 2012, observers reported 24 Kemp's ridley (*Lepidochelys kempii*) sea turtles captured aboard southeast US skimmer trawl vessels targeting penaeid shrimp. The size distribution of turtles captured was small with 58% having body depths (BD) less than 4-inches (10.2 cm), which could allow them to pass through maximum 4-inch Turtle Excluder Device (TED) bar spacing proposed for the fishery. Examination of in-water and stranding data indicated that reducing TED bar spacing to 3-inches (7.6 cm) would prevent > 97% of sea turtles from passing through deflector bars. In June 2014, researchers addressed this issue through a sea turtle exclusion study with reduced bar spacing TEDs. Captive-reared, one year-old loggerhead (*Caretta caretta*) and Kemp's ridley sea turtles were exposed to a variety of TED treatment configurations to examine escape rates. Logistic regression analysis identified species ($p < 0.0001$), TED type ($p < 0.0163$), and flap twine size ($p < 0.0001$) as significant predictors of turtle capture. The same TED configurations examined for turtle exclusion were evaluated for target shrimp retention in 2013 and 2014. Results indicate increased catch loss with finer twine (1.8 mm) TED flaps when compared to traditional (2.3 mm) flaps.

Trawl Gear Evaluation and Turtle Excluder Device (TED) Certification Testing

Contact: Jeff Gearhart (Jeff.Gearhart@noaa.gov)

TED testing utilizing the small turtle test protocol (Federal Register, Vol. 55, No. 195) was conducted in Panama City, FL, June 9-23, 2015. The project was performed aboard the RV Caretta, a 19.8 m twin trawl vessel. The TEDs tested consisted of designs developed for use in various shrimp and finfish fisheries. One three year-old (Cc2012), 197 two year-old (Cc2013), and 30 one year-old (Cc2014) loggerhead (*Caretta caretta*) sea turtles were obtained from the NOAA Fisheries Galveston, TX head start facility for the project period. All turtles were raised from hatchlings collected from nests on Melbourne Beach, FL with all of the one year-olds and 93 of the two year-olds used in TED tests. There were a total of 200 TED trials conducted in 2015. After testing was complete, all one year-old turtles were returned to Galveston, TX, while the three year-old and two year-old turtles were transported to Fort Pierce, FL where they were released at the edge of the Gulf Stream. TED certification testing will continue in 2016.

Using the DIDSON acoustic camera to evaluate dolphin depredation of skimmer trawls in the Mississippi Sound

Contact: Dominy Hataway (Bret.D.Hataway@noaa.gov)

Skimmer trawls are an effective method of catching Penaeid shrimp in the shallow coastal waters of the north-central Gulf of Mexico, including Mississippi Sound. As with many warm-water shrimp trawl fisheries, the bycatch of finfish can be a significant proportion of the total catch. Consequently, trawl damage due to the depredation of fish by bottlenose dolphin (*Tursiops truncates*) is a persistent problem in the fishery. A pilot project was conducted to examine the feasibility of using DIDSON (Dual frequency Identification Sonar) as a tool to image dolphins interacting with skimmer trawls in the turbid waters of Mississippi Sound. Using the DIDSON we hope to gain a better understanding of dolphin behaviour during trawl interactions as a first step in developing mitigation measures. During the project, one net was monitored for dolphin interactions and assessed for bite holes in the netting at the end of each fishing day. At total of 63 tows were conducted resulting in 185 bite holes made by dolphins. The holes ranged in size from a single broken mesh to holes approximately 9 inches (22.9 cm) across. Our observations indicated that dolphins tend to bite the net more often on the bottom panel and starboard wing. Monitoring of the net by the DIDSON as well as surface observations showed that while the catch is being hauled, fish accumulate in the starboard wing and bottom of the net where they are heavily preyed upon by dolphins. These evaluations have provided useful information that may assist in the development of possible mitigation measures.

Shrimp Trawl Bycatch Reduction Device (BRD) Evaluations

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

Shrimp trawl Bycatch Reduction Device (BRD) development trials were conducted aboard the RV Caretta over three separate cruises in 2015. Comparative tows were conducted to evaluate a prototype BRD designs developed by the University of Mississippi. Based on the 2015 results, modifications will be made to the BRD design in preparation for further testing in September of 2016.

Flynet TED Evaluations

Contact: Jeff Gearhart (Jeff.Gearhart@noaa.gov)

Flynet TED evaluations were conducted aboard the contracted 22.6 m commercial trawler located in Wanchese, NC. Two legs were conducted off the North Carolina and Virginia coast in federal waters beyond three miles. The vessel towed a single 25.9 m headrope length flynet. Tow times were limited to 90 minutes and an alternate haul testing ABBA format was used for the duration of each trip, where A was a control tow with no TED installed and B an experimental tow with a TED installed. Additional testing is planned for 2016.

North Carolina Division of Marine Fisheries

Gear Development Program, Morehead, NC

Contact: Kevin Brown (Kevin.H.Brown@ncdenr.gov)

Technical solutions to reduce bycatch in the North Carolina shrimp trawl fishery

In 2012, the North Carolina Marine Fisheries Commission (MFC) voted to amend the Shrimp Fishery Management Plan (FMP), limiting the amendment focus to finfish bycatch issues. In 2014, the MFC selected FMP management strategies, one of which was to: *"…convene a stakeholder group to initiate industry testing … to reduce bycatch to the extent practicable with a 40% target reduction. Upon securing funding, testing in the ocean and internal waters will consist of three years of data…. Results should minimize shrimp loss and maximize reduction of bycatch of finfish. Promising configurations will be brought back to the MFC for consideration for mandatory use."* The MFC also provided additional guidance concerning group representation, the specifications of control nets to be used in BRD testing, and the review process for possible implementation of mandatory use of promising configurations. The control net was established as the industry standard and includes a federally certified Turtle Excluder Device (TED), a state certified BRD, and a 1-½ inch stretch mesh tailbag. The N.C. Division of Marine Fisheries in collaboration with NOAA-Harvesting Systems Unit and North Carolina Sea Grant formed an industry workgroup, representing a wide geographic range of shrimpers, netmakers, and industry leaders in North Carolina. The workgroup was formed to provide industry input and select BRDs to be tested. Three BRDs were tested in the 2015 summer brown shrimp (*Farfantepenaeus aztecus*) fishery. Preliminary results were promising and showed minimal shrimp loss (-2.7% to +1.5%) and up to a 38% reduction in finfish bycatch. The work group reconvened in early 2016 to discuss these results and establish gears to be tested in 2016. This second year of testing will include three BRDs in the summer brown shrimp fishery and three BRDs in the fall white shrimp (*Litopenaeus setiferus*) fishery.

Pacific States Marine Fisheries Commission

Pacific Fisheries Bycatch Program, Newport, Oregon

Contact: Mark J.M. Lomeli (mlomeli@psmfc.org; http://www.psmfc.org/bycatch/)

Evaluation of a sorting grid bycatch reduction device for the selective flatfish bottom trawl in the US west coast fishery

Contact: Mark Lomeli and W. Waldo Wakefield (NMFS-Northwest Fisheries Science Center, NWFSC)

The US West Coast limited entry groundfish trawl fishery is managed under an individual fishing quota program. For many fishers targeting flatfish in this fishery, catches of rockfish (*Sebastes* spp.), sablefish (*Anoplopoma fimbria*), and Pacific halibut (*Hippoglossus stenolepis*) can be a concern because quota is limited relative to flatfish quotas. Thus, approaches to minimize bycatch of limiting species are important to the economic viability of the fishery. In this study, we examined the size-selection characteristics of a flexible sorting grid bycatch reduction device (designed to retain flatfish while reducing catches of rockfish, sablefish, and Pacific halibut) using a recapture net. The mean codend retention of target flatfish (five species evaluated) ranged from 68.1% to 92.3%. Combined, the mean flatfish retention was 85.6%. Codend catches of shelf rockfish, slope rockfish, sablefish, and Pacific halibut were reduced by 80.3%, 64.0%, 97.0%, and 90.3% by weight, respectively. Significant differences in selectivity parameters between flatfish, rockfish, sablefish, and Pacific halibut were observed. Overfishing grounds where fishers need a more selective trawl to harvest flatfish, the experimental gear tested could provide fishers a technique to reduce catches of non-target species. Segments of video footage from this study can be viewed at: http://www.psmfc.org/bycatch/videos.html

Artificial light: Its influence on Chinook salmon escapement out a bycatch reduction device in a Pacific whiting midwater trawl

Contact: Mark J.M. Lomeli and W. Waldo Wakefield (NMFS-NWFSC)

The Pacific whiting (*Merluccius productus*) midwater trawl fishery represents the largest groundfish fishery by volume along the US west coast. While landed catches consist of mostly Pacific whiting, bycatch of Chinook salmon (*Oncorhynchus tshawytscha*) is an issue affecting the fishery. Although the catch ratio of Chinook salmon caught in the fishery is typically < 0.03 fish per metric ton of Pacific whiting, bycatch is a concern because of the high volume of the fishery and the incidental capture of Endangered Species Act listed salmon. In this study, we examined the use of artificial light as a technique to reduce Chinook salmon bycatch. Specifically, we tested if Chinook salmon can be attracted towards and out of specific escape windows of a bycatch reduction device (BRD) using artificial light. Data on fish behaviour and escapement was collected using underwater video camera systems. During sea trials, video observations were made on 437 Chinook salmon with escapement occurring in 298 individual (68.2% of fish). At trawl depths, 266 Chinook salmon escaped with 230 individuals (86.5% of fish) exiting out a window that was illuminated. This result was highly significant ($p < 0.00001$). These data show that light can influence where Chinook salmon exit a BRD, but also suggest that light could be used to enhance their escapement overall. Segments of video footage of Chinook salmon observed during this study can be viewed at this website: http://www.psmfc.org/bycatch/videos.html

Size-selectivity of T90 mesh and diamond mesh codends on five groundfish species commonly caught over the upper continental slope of the US west coast

Contact: Mark J.M. Lomeli, Owen S. Hamel (NMFS-NWFSC), W. Waldo Wakefield (NMFS-NWFSC), and Daniel L. Erickson (Oregon Dept. Fish and Wildlife)

The US west coast groundfish bottom-trawl fishery operates under a catch share program, implemented with the intention of improving the economic efficiency of the fishery, maximizing fishing opportunities, and minimizing bycatch. However, stocks with low harvest guidelines have limited fishers's ability to maximize catch of more abundant stocks. Size-selection characteristics of 114 mm and 140 mm T90 mesh, and traditional 114 mm diamond mesh codends were examined using the covered codend method. Selection curves and mean L_{50} values for two flatfish species (rex sole *Glyptocephalus zachirus*, and Dover sole *Microstomus pacificus*), and three roundfish species (shortspine thornyhead *Sebastolobus alascanus*, longspine thornyhead *S. altivelis*, and sablefish *Anoplopoma fimbria*) were estimated. Mean L_{50} values were smaller for flatfish, but larger for roundfish in the 114 mm T90 codend compared to the diamond codend. The 140 mm T90 codend showed significantly different selectivity from the others, being most effective at reducing the catch of unmarketable-sized fish, however with a considerable loss of marketable-sized fish. Findings suggest T90 codends have potential to improve catch utilization in this multispecies fishery.

NOAA Fisheries Alaska Fisheries Science Center

Conservation Engineering Group, Seattle, WA

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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. John's, Newfoundland. The North Pacific Fisheries Research Foundation placed a technician aboard Gulf of Alaska vesselsb 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." Tests in 2013 and 2014 of the new over/under design in the Gulf of Alaska trawl fleet show escapement rates for salmon between 35–54%. Pollock escape was insignificant at less than 1%. In 2015 and early 2016 the over/under design was tested in the Bering Sea pollock fleet with only about 10% escapement of salmon and about 1% pollock escapement. It is unclear at this time why the salmon escape rates are so different between the two different fleets. 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.

Halibut excluders – RACE MACE Conservation Engineering

In 2015 halibut bycatch quota in the Bering Sea/Aleutian Islands (BSAI) groundfish fisheries was significantly reduced by 21% across four different fishing sectors. CE scientists collaborated with fishing gear manufacturer's and fishers to test different halibut excluder designs. The basic design concept is a squared mesh tunnel inside the net, target species pass through the tunnel and into the codend, species (halibut, skates, etc) that cannot fit through the square mesh tunnel stay inside of the tunnel and escape out the escape hole. The design tested in pollock trawl fleet showed too high a loss of target catch and the manufacturer is working to redesign it. There are several different configuration of the base concept being tested in the bottom-trawl fleet with very promising results to so far. We hope to do more rigorous testing in 2017.

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 of 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 began exploring these possibilities with experiments to compare the seabed effects of the different alternative footropes. Preliminary results show that we reduced footrope contact with the seabed by at least 90%. We are still working on analysing the data to determine impacts to benthic structure forming organisms. CE cooperative research moving forward includes work with industry to adapt the prototype footropes tested in 2014 for regular commercial use and full-scale tests of the resulting designs to confirm commercial effectiveness in 2017.

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

We have continued to provide 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. 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 9 x 5 inches and is of nearly neutral buoyancy in water. These systems have been in use for about 3 years now and have proven to be very easy to use, durable and flexible. Six new systems have been built for our use and as replacements of the older loaner systems. While this design is so inexpensive and functional that many vessels have acquired their own systems, there is still a need for loaner systems.

11.6 Sweden

Swedish University of Agricultural Sciences

Department of Aquatic Resources, Institution of Aquatic Resources, Lysekil

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Gear development in Sweden 2015

Since 2014, focus on fishing gear development in Sweden are tightly linked to the introduction of EU's landing obligation.

With new fisheries policy proposal by EU commission in 2011 and with the decision in 2013 there is a new common fisheries policy for the EU. The new fisheries policy is to ensure that fisheries and aquaculture are environmentally sustainable and administered in a way where the long-term aims of food security is achieved both economically and socially.

Some of more important components in the new fisheries policy are among others long-term ecosystem-based management and the requirement that latest in 2020 all stocks are to be fished in a way, which support their MSY. Moreover, will there be a phasing of a landing obligation on all stocks subjected by a quota, as discard are considered a threat to a long-term use of aquatic resources. The landing obligation includes landing of all species that are subjected by quotas and where all landings are to be counted from the total quota. The new strategy is intended to urge the development of more selective fishing methods along with generate more reliable catch data. Thus with selective fisheries the intention is to catch the right species of the correct size at the right time. The landing obligation was introduced in 2015 and is to be entirely implemented in 2019, throughout the main part of the commercial fisheries within the EU. In the Baltic along with pelagic fisheries throughout EU the landing obligation was introduced January 1, 2015. However, there are exclusions to the landing obligation linked to whether the fishing method allows that a species is to be released with high probability of survival or if the catch of an untargeted species within a certain fishery is below 5%.

To promote a more selective fishing and assist the commercial fisheries in the introduction of the landing obligation Aquatic Resources at Swedish Agricultural University (SLU-Aqua) have founded the "Secretariat for Selective Fishing". The secretariat is assigned by the Swedish Agency for Marine and Water Management (HaV) and will from 2014 until 2017 administer a special effort in selective fishing gear development, financed by the Swedish government. The assignment for SLU-Aqua is to assist the commercial fisheries to projectify their ideas regarding needs and general ideas to increase the fisheries selectivity. Furthermore, is SLU-Aqua represented in the steering committee, along with HaV and Swedish Board of Agriculture, which responsible for the decision-making of which project is to be founded in accordance with priorities by the committee. The Secretariat for Selective Fishing than carry out the projects in close cooperation with the commercial fishers, both experimentally along with being responsible for the scientific evaluation along with giving advice back to the agencies and government.

Projects 2015

During 2015 the Secretariat for Selective Fishing at SLU-Aqua, along with Swedish commercial fishers, performed in total nine projects within the government commission in developing more selective fishing gear and through that facilitate for the implementation of the landing obligation. The focus was to decrease the amount of non-targeted catch within the Swedish fisheries either by evolving existing gear types (predominantly trawl fisheries) or by developing alternative gear types and methods (preferably in passive gear as traps and pots).

Combination grid for Northern shrimp

If there is a possibility to provide shrimp trawls with a dual selection grid, a Nordmøre 19 mm grid along with one smaller sized grid, in order to release small sized shrimp. The results showed that with a 9 mm second grid a larger proportion of shrimp with a carapace less then 20 mm was released, however the method was density-dependent.

Selectivity adapted for small sized shrimp trawlers

In respect to their size it is difficult for smaller shrimp vessels to handle combination grids equipped trawls. One solution could be to include hoses/compartments of larger mesh size within the trawl to allow for larger shrimp to follow the larger mesh sizes into the compartments and the smaller individuals are to be sorted out through the funnels into the codend. The initial experiments showed that the gear design needs improvements before it may be evaluated regarding its size selectivity of northern shrimp.

Shrimp pots

The project intends to evaluate the potential for shrimp potting in Sweden. In total six different pot types were tested. The best performing pot type was a large model distinct from other models by having the entrances at the sides instead of at the top. The same pot also showed to catch Norwegian lobster as a positive bycatch species.

Evolution of size selective grid in the Norwegian lobster fisheries

There is an ongoing need for improving the species and size selectivity in the Norwegian lobster fisheries. The project included an evaluation of a new trawl layout. The new trawl type showed a to be more size selective towards smaller individuals (-60 weight %) while the larger individuals (< 40 mm carapace) decreased with 12 weight %. Moreover, there was a 50–90% weight decrease in groundfish (cod and whiting) and flatfish (plaice, dab, and American plaice).

Trawl for flatfish and large cod

The Swedish west coast fisheries include both groundfish and flatfish species. With the introduction of the landing obligation there is a risk of enclosure as the groundfish quota is filled. The project includes the evaluation of a grid that will diverge groundfish and flatfish in different parts of the trawl. The project was a success in the sense that the species selection worked properly and the trawl caught fewer but larger cod.

Improved selectivity in Baltic cod trawls

The project evaluated a improved trawl where the codend was of T90 type but the mesh number was increased from 50 to 80 and the mesh size decreased from 126 to 118 mm. The experimental trawl showed higher selection towards legal sized cod in the size range 38 to 52 cm, while individuals less then 35 cm in length were sorted out to a higher extent.

Pollock selectivity in pelagic trawls

The project sought a solution for the large quantity of pollock bycatch within the herring fisheries. A polyurethane grid made of 6 x 3, 60 x 100 cm panels was deployed in a 70° angle in the trawl. The reduction of pollock was 92–96% while the herring loss was in the order of 2.7–15% of the catch.

Species selective pontoon-trap

The pontoon-tarp fisheries in Bothninan bay expose and may potentially harm the migratory Atlantic salmon. In order to allow for the whitefish fisheries to be conducted also during periods of salmon fishing ban better species selection methods are needed. Two methods were evaluated, a net which was supposed to hinder salmon but allow whitefish to enter the trap and selection panels. Both methods reduced the catch of salmon, however the also reduced whitefish catch significantly.

Multi purpose pots for combined lobster and cod fisheries

The purpose was to evaluate a combined pot for catching both lobster and cod in the small-scale coastal fisheries, and trough that increase the gain. In total three pot models (sizes) were evaluated in relation to a commercial lobster pot. The catch of cod increased with increased pot size, where the smallest model caught cod in the same range as the standard lobster pot. Also for lobster was the catch higher was higher in the larger pot compared with the standard pot.

Projects 2016

As the government commission for selective fishing are on going until 2017, projects for 2016 are under consideration and processed by the secretariat. For 2016 up until now, three projects have been granted founding within the framework of Secretariat for Selective Fishing: Selective pontoon-trap for cod the Baltic cod fisheries, mackerel pontoon-trap and pots for capturing flatfish, predominantly turbot in the Baltic.

11.7 Scotland

Marine Scotland Science

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

Contact: b.oneill@marlab.ac.uk or k.summerbell@marlab.ac.uk

Experimental sea trials were carried out on the RV Alba na Mara during May 2015 in the inner Moray Firth, Scotland to collect experimental data with which to validate the numerical methodology. The grounds worked were (i) approximately 8 miles east northeast of Tarbat Ness and (ii) in the Dornoch Firth.

The results show that for the fixed cylinders and disks on the sandier sediment there is a reduction in drag as towing speed increases which is likely to correspond to the gear components penetrating the seabed to a lesser depth at higher speeds. This effect is more pronounced for the heavier components, which probably reflects that heavier components penetrate deeper in the first instance and have more scope to vary penetration as speed increases. When these components roll on the same sediment, there is no such effect, however, there is when they roll on the muddier sediment, which suggests that there is little penetration of rolling disks and cylinders into the sandier sediment whereas there is into the muddier one.

A meta-analysis of horizontal panel separation data of fish at the mouth of a trawl

Contact: b.oneill@marlab.ac.uk

A meta-analysis of horizontal panel separation data from 20 trials conducted in the North Sea and Northeast Atlantic between 1972 and 2015 was carried out. The effect on separation of explanatory variables such as the height of the panel, the distance of the panel from the groundgear, and the time of day in which trawling took place were considered. Results are presented for eight species: the gadoids cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*), saithe (*Pollachius virens*) and whiting (*Merlangius merlangus*), the flatfish lemon sole (*Microstomus kitt*) and plaice (*Pleuronectes platessa*), and monkfish (*Lophius piscatorius*) and Nephrops (*Nephrops norvegicus*). As would be expected, the proportion of fish retained in the upper codend decreases as the separator height increases for all species except for monkfish and *Nephrops*. For monkfish and Nephrops, some individuals do enter the upper codend when the separator height is low, but there is insufficient data to explore this further. The proportion of cod in upper increases as distance from groundgear increases and the proportion of plaice in the upper codend is greater at night.

Effects of Codend Mesh Size and Lifting Bag on Nephrops Selectivity

Contact: j.drewery@marlab.ac.uk

Trials were conducted in the West Coast to examine the effect of mesh size and lifting bag on the selectivity of *Nephrops* (*Nephrops norvegicus*). The following four codends were tested with regards to codends of the following mesh size and construction:

- 80 mm diamond mesh codend of 4 mm single Brezline (PE) twine both with and without a lifting bag (here designated 80 mm and 80 mmL)
- 100 mm diamond mesh codend of 5 mm double Brezline (PE) twine both with and without a lifting bag (100 mm and 100 mmL)

For *Nephrops* there are trends apparent with regards to selectivity in that the order of selectivity in decreasing value is 100 mm, 100 mmL, 80 mm, and 80 mmL. However only 100 mm and 80 L were observed to be significantly different from each other. For whiting (*Merlangius merlangus*) the trend is similar. At 22 cm the catch rates are 8%, 30%, 45%, and 48% in order as above. For haddock (*Melanogrammus aeglefinus*) catch rates are not significantly different from 100% in 80 mmL and 100 mmL for fish greater than 19 cm and 20 cm respectively.

Investigating the use of light to promote the selectivity of towed gears.

Contact: b.oneill@marlab.ac.uk, or k.summerbell@marlab.ac.uk

Two sets of fishing trials took place on the RV Alba na Mara on fishing grounds east of the Orkney Islands. A prawn trawl with a separator panel was fished and side emitting fibre optic light cables were attached to the fishing line and to the leading edge of the horizontal separator panel. Fish that went above the panel were caught in the upper codend and fish that went below the panel were caught in the lower codend. The first set of trials took place in September 2014 during daylight hours when 34 fishing tows took place. Two different panel heights (approximately 20 and 60 cm) were tested, both with and without a light cable attached to the leading edge of the panel. The second set of trials took place in March 2015 during the night and 26 fishing tows took place. Haddock, whiting, cod, lemon sole, plaice, gurnards, common dab and long rough dabs were caught and measured. The light cables only seemed to affect behaviour (except maybe for common dab) when used during the night. Fewer fish enter the upper codend during night-time tows with the light cable switched on. It is not clear whether the fish are reacting directly to the light cable or perhaps to something associated with the additional illumination provided by the light cable.

An investigation into the commercial viability of fish traps and jig fishing on the West Coast of Scotland

Contact: Jim Mair (james.mair2@gov.scot)

Four Marine Scotland designed fish traps, proven in the past to capture large amounts of commercial fish, were deployed at various locations on the west coast of Scotland.

The object of the study was to ascertain the advantages of using autojiggers and a small number of traps to capture commercially viable amounts of fish and shellfish with zero discard mortality and little or no benthic impact.

Deployments were made on in shore crab grounds and catches have been reasonable from the ten deployments to date, with a variety of fish and shellfish caught.

Two new model Belitronic 5000e autojiggers will be used to fish at six wrecks near Stornoway in the second period of the project to ascertain if traps can be viable for the capture of larger gadoids in conjunction with jigging.

The Gear Innovation Technology and Advisory Group (GITAG)

Contact: Malcolm Morrison (m.morrison@sff.co.uk)

The Gear Innovation Technology and Advisory Group (GITAG) has been set up to encourage skippers and fishers from all sectors to put forward innovative ideas for more selective gears which will help their targeted fishery become more sustainable.

The Group was formed in the second half of 2015 after the Scottish Fishers's Federation's wholly owned subsidiary company SFF Services had secured funding from Marine Scotland to develop and trial innovative fishing gear exploring practical solutions aimed at reducing the amount of discards.

GITAG aims to address these research and development gaps by working with key partners including industry, Marine Scotland Policy, Marine Scotland Science, Producer Organizations, the Scottish Industry Discards Initiative and Seafish to promote and encourage innovation from the fishing industry as a whole.

A first phase of this project has seen four applications come forward from skippers for various different gears to be trialed in different locations. A second phase will be developed over the next months in consultation with industry to develop further trials with the purpose of assisting skippers manage their responsibilities under the landing obligation. Phase two will look to work with all sectors and will develop gears which will offer choice of options and solutions over the coming years. Projects which are taken forward under GITAG will have trial gear and charters fully funded with derogations to cover quota and days where appropriate.

Trials to compare the catchability of a bobbin groundgear (B rig) against a new rock-hopper groundgear (E rig) for the Scottish GOV trawl using groundgear collection bags

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Since 1985, the Scottish GOV trawl has been fished with a 305 mm rubber wheel bobbin groundgear (B rig) on all stations north of 57°30'N during the North Sea internationally coordinated bottom-trawl surveys (IBTS). Many of the components used in is construction have become obsolete and are unavailable or uneconomic to manufacture. These trials were the first stage in developing a replacement groundgear for the B rig.

The new rock-hopper groundgear (E rig) incorporated 300 mm discs in the centre reducing to 250 mm at the wingends. The gear was rigged onto 16 mm mid link chain and incorporated a traveller chain constructed from 13 mm short link chain. The trials were conducted on the Marine Scotland Science research vessel Scotia from 4 to 15 November 2015 on fishing ground in the North Sea. The catchability of both groundgears were assessed using 3 groundgear collection bags attached to the fishing line of a GOV trawl and rigged so they followed the path covered by both groundgears. A total of 13 hauls were completed with the rock-hopper groundgear and 14 with the bobbin gear. At the time of writing this report the data are due to be analysed during summer 2016

11.8 Belgium

Institute for Agricultural and Fisheries Research (ILVO)

An optimized pulse trawl design for a selective Crangon fishery

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Current technical modifications aiming for bycatch reduction in the North Sea Crangon fishery, like sieve nets, focus on catch separation or filtering after species have entered the trawl. Sieve nets are satisfactory effective in avoiding the bycatch of relatively large individuals of all species, but less so at reducing 0-group plaice and sole. Because of this drawback alternative measures are recommended. The fundamental idea behind the pulse fishing technique for shrimp is to reduce or remove the relatively heavy bobbin rope and use electrical pulsation as a stimulation alternative. The use of a specific electric field close to the seabed induces a startle response in shrimp and leaves other organisms unaffected. Herein lays the selective fishing potential of this alternative technique. Preservation of commercial catch rates and sufficient reduction of bycatch and seabed contact are the decisive criteria in the evaluation of the different pulse gear designs. Intensive, year-round testing of an optimized electrotrawl on a commercial shrimp cutter on the Dutch Wadden Sea, revealed important results. Direct catch comparison with a standard shrimp trawl indicated that at least as much shrimp can be caught with this specific electrotrawl design. On top of that, an average bycatch reduction of 58% in volume is a major step forward in dealing with the discarding practices in the brown shrimp fishery. Additionally a 65% reduction in seabed contact is a radical change in the environmental impact issue associated with this coastal fishery.

Can liquefied natural gas (LNG) be an alternative for gasoil in the Belgian fishery?

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Injury, reflex impairment, and survival of beam trawled flatfish

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Under the 'high survival' exemption of the European landing obligation or discard ban, monitoring vitality and survival of European flatfish becomes relevant to a discard-intensive beam trawl fishery. The reflex action mortality predictor (RAMP) method may be useful in this context. It involves scoring for the presence or absence of natural animal reflexes to generate an impairment score which is then correlated with post-release or discard mortality. In our first experiment, we determined suitable candidate reflexes for acclimated, laboratory-held European plaice (*Pleuronectes platessa*) and common sole (*Solea solea*). In a second experiment, we quantified reflex impairment of commercially trawled-and-handled plaice and sole in response to commercial fishing stressors. In a third experiment, we tested whether a combined reflex impairment and injury (vitality) score of plaice was correlated with delayed post-release mortality to establish RAMP. Five-hundred-fourteen trawled-and-discarded plaice and 176 sole were assessed for experimentally confirmed reflexes such as righting, evasion, stabilize, and tail grab, among others. Of these fish, 316 plaice were monitored for at least 14 days in captivity, alongside 60 control plaice. All control fish survived, together with an average of 50% (± 29 SD) plaice after being trawled from conventional, 60-min trawls and sorted onboard a coastal beam trawler. Stressors such as trawl duration, wave height, air and seawater temperature, were not as relevant as a vitality score and total length in predicting post-release survival probability. In the second experiment where survival was not assessed, reflex impairment of plaice became more frequent with prolonged air exposure. For sole, a researcher handling-and-reflex scoring bias rather than a fishing stressor may have confounded results. Scoring a larger number of individuals for injuries and reflexes from a representative selection of trawls and trips may allow for a fleet-scale discard survival estimate to facilitate implementation of the discard ban.

The fate of discards from marine fisheries: A disregarded viewpoint in fisheries management

Jochen Depestele

http://pure.ilvo.vlaanderen.be/portal/nl/publications/the-fate-of-discards-from-marine-fisheries(0e704f08-fe52-4605-910a-09e0621a8da6).html

Electrofishing: Exploring the safety range of electric pulses for marine species and its potential for further innovation (PhD thesis)

Maarten Soetaert

http://pure.ilvo.vlaanderen.be/portal/files/3983522/Doctoraatsthesis_Maarten_Soetaert.pdf

VALDUVIS: An innovative approach to assess the sustainability of fishing activities

Arne Kinds, Kim Sys, Laura Schotte, Koen Mondelaers, Hans Polet

The Belgian fishing sector is under pressure to demonstrate the sustainability of its fishing methods. First, the beam trawl (which accounts for 80% of the landings) is contested due to its low selectivity and significant disturbance of the seabed. Second, the Belgian retail market has committed to sourcing sustainable seafood. However, converting to sustainable methods is costly and may not be feasible for the majority of fishers who have suffered economic losses in the wake of the 2008 fuel crisis. Instead of a full-scale transition to sustainable fishing, fishers have developed modifications to the beam trawl that reduce environmental impact and save fuel. We propose an indicator-based sustainability assessment tool (VALDUVIS) that recognizes these efforts and offers incentives for fishers to adopt more sustainable fishing practices. In this article, we describe the development of the tool and its potential applications. Integrated Sustainability Assessment (ISA) was used as a framework to develop the tool and to initiate the transition towards sustainability in the Belgian fishery. VALDUVIS offers a promising new method to assess sustainability in fisheries. The approach is innovative in several ways. First, indicator scores are calculated using official data flows (e.g. the electronic logbook), which enhances traceability and provides the possibility of communicating sustainability data soon after landing the fish. Second, indicators are scored on a fine scale (e.g. per fishing trip). Third, stakeholder participation was essential in the development of the tool. This enhanced the support of the wider fishing sector and assured the relevance of the indicators and the users' understanding of the tool. Fourth, the delivered tool is multi-purpose and can be easily adapted to the needs of a range of end-users (fishers, wholesalers, retailers, authorities, researchers, etc.). The VALDUVIS tool offers a cost-effective alternative to known certification schemes that could be applied to any type of fishery. The Belgian fishing sector considers VALDUVIS to be suitable for monitoring the progress towards sustainability as well as for providing incentives for fishers to adopt better practices.

Towards a better understanding of the adoption of new fishing technology by Belgian fishers

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In Western Europe, fish stocks are under pressure and as a consequence so are their associated fisheries. In addition, fishing, and particularly practices employing towed bottom contact gears, have a major impact on benthic ecosystems (Løkkeborg, 2005). This is the case for the mixed demersal fishery in the North Sea. In the Belgian fleet 77% of the landings is accounted for by beam trawlers (Tessens, 2015).

For these reasons, technical and management measures are being developed in an attempt to lower the impact of fishing. The choice of fishing technique can make a large difference in impact on the ecosystem as well as in efficiency (e.g. fuel consumption). In addition, when considering a particular gear, there exists a broad series of possible measures to improve selectivity and reduce the number of unwanted species and undersized fish. These measures are often developed by the industry or in science-industry partnerships. Measures such as escape panels, lighter netting, replacement of the traditional beam with more hydrodynamic structures (e.g. sumwing), replacement of the trawl heads with rollers (e.g. ecoroll beam) have proven successful in reducing bycatch, fuel consumption or bottom impact (or a combination of these) (Depestele *et al.*, 2007; Polet *et al.*, 2010; Poos *et al.*, 2013).

However, the diffusion of technical innovations in fisheries has been observed to be a slow process. As is the case in the agricultural sector, it can be assumed that the adoption of new technologies rarely happens on its own and adoption decisions are very likely to be influenced by changes in external factors (Wauters *et al.*, 2005; D' Emden *et al.*, 2006). Therefore, the focus of this study is to identify the factors associated with the decision to adopt and invest in new fishing technology. This study is a first attempt to investigate the drivers and attitudes behind the uptake of new fishing technologies by Belgian fishers.

Fifteen Belgian fishers were selected and invited for a semi-structured open interview in the period January-March 2016. Prior to the interviews, we listed a set of possible themes related to fisher attitude and behaviour. Additional themes that come up frequently during the interviews will be recorded, as well as the perceived link between themes and mentioned associations. These will be described and divergent views will be used to challenge generalizations. The results are expected to indicate that besides profitability, a number of other drivers play a role in adoption behaviour and investment decisions (social relationships among fishers, external factors such as subsidies and fuel prices, pressure from the producer organization or policy-makers, etc.). Knowing the factors that hamper or facilitate the adoption of innovative techniques can be important for the implementation of management measures aiming for sustainable fisheries.

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11.9 Norway

Institute of Marine Research (IMR)

Catch release system for demersal seines

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With today's large cod stock, it has become a great challenge for the demersal seine fleet to limit their catch sizes. Incidents with hauls of tens of tons have been recorded, often too large for the boats to handle and causing safety risks for the smaller boats. 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 resulted in a functional solution that has gained industry acceptance. Researchers fro IMR and the Fisheries Directorate have travelled with boats from February through April 2015 and filmed the catch control device using underwater cameras. Some modifications have been done to adjust the solution to the different seines in use, but overall, the solution has proved to perform successfully to limit catch sizes without loosing fish at low catch rates. The Norwegian demersal fleet has temporary dispensation to use the system and reports to the

Directorate of Fisheries. Based on fishers experiences and underwater observations in 2015, the system has been subjected to minor modification for improving the functionality.

Species separation of cod and haddock in demersal seines

Contact: Ólafur Arnar Ingólfsson (olafur@imr.no)

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 1990s. 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 were performed in august 2014 on board a commercial seiner in the Barents Sea. A horizontal square mesh panel was attached to the belly section and fish from the upper and lower sections were collected in two separate codends. Further testing was done in 2015 on board a commercial vessel. The species separation is length dependent, and larger proportion of the smallest fish end up in the upper compartment. The results, however, show that separation of cod and haddock is feasible up to a certain extent; about 80% of haddock end up in the upper codend, while about 90% of cod were retained in the lower codend.

Species selection of cod and flatfish in demersal seines

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

Demersal seiners above 15 m in length are prohibited to fish for plaice and lemon sole inside the fjord areas in Norway due to bycatches of coastal cod. In this project, the objective is to catch flatfish but exclude cod. Following a pre-study of fish behaviour in 2014, a tank test and three surveys with a demersal seine were conducted. The seine that was tested had a vertical opening of 0.6–0.7 m and had a fishing line of 10 m. It was fished both with and without wing extensions of 20 m. The gear was frequently set in areas with dense fish registrations on echograms. Cameras without light were mounted on various locations filming both gear and fish behaviour. The seine caught flatfish, but cod and haddock mostly passed above the fishing line. In over 40 hauls, only two specimens of cod and two of haddock were caught. Plaice was the most predominant species caught. Catches varied, the largest catch being 1500 kg. Catches of lemon sole, halibut and monkfish were greater when the wing extension was added, while plaice catches were not significantly influenced by wing length.

Size selection in the shrimp fisheries

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

In 2016, IMR runs a project on the effect of modifying trawl design on size selection of shrimp. In some previous studies, observations have been made that catches of small shrimp, as well as bycatches of small fish, have changed with alterations in trawl design. The project is run in collaboration with fishers and fishing gear designers.

Catch release system for demersal trawls

Contact: Ólafur Arnar Ingólfsson (olafuri@imr.no)

In recent years, it has become a great challenge for the demersal trawler fleet to limit their catch sizes. The past several years, IMR has been working on solutions for limiting catches by releasing excessive fish from the codend. In 2015, underwater observations were made in the cod fisheries in the Barents Sea. Early 2016, further tests and observations using both remotely operated cameras and fixed camera systems. Modifications of the system were made as well as experimenting with alternative solutions. About half of the Norwegian trawler fleet has temporary dispensation to use the system and reports to the Directorate of Fisheries.

Sampling trawls with ruffled small mesh liner nets

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

Work has continued with "ruffled" 8 mm mesh liner panels inside sampling trawls to reduce the clogging of small individuals (young of the year fish and zooplankton). The liner nets are installed as a series of overlapping cylinders inside the trawl, and are attached only at the leading edge so that they wave gently with the water current. Flume tank tests of a scale model for a new trawl for macro zooplankton led to the conclusion that the panels should have 30% less circumference than the trawl in order to ensure they do not simply cling to the larger outer trawl meshes. It was also apparent that each panel could be constructed as a cylinder, rather than a cone, which eliminates the need to maintain a cutting ratio in such small meshes and greatly simplifies construction. A new trawl was built in full-scale based on these design characteristics and proved successful in eliminating clogging in all but the aftermost part of the extension, where the trawl tapers more abruptly into a multisampler. A new, longer and more gently tapered extension has been designed and will be tested in 2016.

Improved catch control in purse-seine fisheries.

Contact: Aud Vold (aud.vold@imr.no)

Earlier experiments at IMR, Bergen, have documented that crowding of pelagic fish like herring and mackerel may lead to mortality among slipped fish, but also that the mortality may be low if slipping is done in a gentle and responsible way at an early stage of hauling. Since these results were known, much effort has been put into developing tools aimed at giving fishers better control of his fishing gear and his catch, and thereby reduce the need for slipping from seines. In addition, it has been an aim to alter the seine designs and rigging to facilitate gentle release if slipping is unavoidable.

At present IMR is working on developing a cannon kite trawl that allows the fishers to obtain a physical sample of a catch encircled by the purse-seine at an early stage of hauling while it is still acceptable to release fish. We are also developing methods that will give the skipper better control of his purse-seine net during setting and hauling, by visualizing the three-dimensional shape of the net on a screen in the wheelhouse using transmitter technology, and by lightening of the float line of the net during hauling at night. Another catch control tool that has been developed is an overspill net that prevents fish from escaping above the float line. This is particularly important in the herring fisheries during winter.

Catch regulation in purse-seine fishing

Contact: Aud Vold (aud.vold@imr.no)

In a project with the goal to develop and implement responsible slipping methods for the purse-seine fleet, the fishing industry, fisheries management and IMR have agreed on a suggestion for a set of guidelines ("Best Practice") for catch regulation from purse-seines when releasing parts of the catch. These guidelines were tested on board commercial purse-seine vessels during 2015. The release opening was monitored using depth tags, while the fish behaviour during slipping was monitored by GoPro cameras attached to the net. The agreed method proved to be practical, flexible and easy to handle for the fishers. Video analyses of mackerel behaviour during slipping showed that until the volume of the net was substantially reduced, the fish were reluctant to leave the seine. When the escape started, it happened rapidly, with the fish swimming out in an orderly schooling structure at the beginning. Towards the end of the escape, the schooling behaviour often got more chaotic and unstructured, which may prove to be negative for the welfare and survival of the escaping fish. More work will be done to improve the slipping process in purse-seine fisheries for pelagic fish.

Fish capture in the vicinity of aquaculture cages

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Norwegian coastal salmon aquaculture attracts large numbers of both pelagic and demersal wild fish to the farming cages. This effect can be in conflict with the interests of fishers because wild fish cannot be harvested close to fish farms due to a 100 m fishery exclusion zone, which is intended to prevent fishing gear from damaging the cages. Earlier studies have shown that aggregations can be harvested using large fish pots set at the bottom underneath the cages at shallow depth (< 50 m). In 2015, a new project was initiated to investigate if pelagic saithe (*Pollachius virens)* could be captured using large pots underneath cages were water depth was too high to allow for bottom-set pots (> 100 m). Pots were deployed at the mooring buoys of salmon cages at depths (10-30m) were saithe was observed both from acoustics and on farm cameras. Saithe were caught in the pots, however huge variation was observed and only a few catches at commercially interesting quantities. Farm cameras showed that saithe aggregations were positioned closer to the net pens (< 10 m), than the closest allowed pot set (~ 20 m), which could explain the high variability.

Ghost fishing by pots

Contact: Terje Jörgensen (terjej@imr.no)

Questionnaires have been used to estimate the loss of pots in the lobster (*Homarus gammarus*) and red king crab (*Paralithodes camtschaticus*) fisheries. For the lobster fishery on the Skagerrak coast the survey indicates a loss rate of approx. 8%. For king crab the survey is not completed yet. To obtain direct estimates of pot loss in an area, we tested strip transects using a ROV and divers for the lobster fishery and side scanning sonar for detecting lost king crab pots. The results indicate that such methodology is not well suited for large-scale surveys. Starting in late 2015, the national diver's association is promoting the retrieval of lost fishing gear by local diving clubs. Provided information on time/location of retrieval, type and state of the gear, and catch is reported to the IMR, a fee of NOK 400 is paid for each gear retrieved. A photo of each gear retrieved should also be attached. At present, several hundred retrievals have been reported, providing highly valuable data on extent and geographical distribution of ghost fishing. To deactivate lost pots we plan to use biodegradable twine (cotton or pulp). Experiments to estimate the degradation rate of the various twines are currently being undertaken.

Selectivity of wrasses

Contact: Terje Jörgensen (terjej@imr.no), Anne Christine Utne Palm (annecu@imr.no)

The last years about 20 million wrasses (mainly corkwing wrasse (*Symphodus melops*) and goldsinny (*Ctenolabrus rupestris*)) have been caught live for use by the fish-farming industry in de-lousing of salmon. The fish are caught on pots and fykenets. Previous studies have shown large quantities (30–70%) of fish of sublegal sizes. Selectivity experiments with rectangular escape vents have demonstrated poor performance of the vents, with high retention of wrasses that based on their sizes could easily have escaped. Installation of a grating (of twine or plastic) in the outer entrance of fykenets effectively prevented the unwanted bycatch of otters, diving seabirds and larger fish specimens, without affecting catch rates of the target wrasse species. Further studies will focus on ways to motivate small fish to escape and include behavioural observations and studies on the effect of size and placement of the vents.

Using artificial light in fish pots

Contact: Svein Løkkeborg (sveinl@imr.no)

A new project was initiated in 2015 to test the effects of using artificial light in pots targeting cod. Underwater camera observations have shown that krill are attracted by light and that cod feed on krill. A fishing trial was carried out last fall comparing pots with artificial light and squid bait with pots baited with squid bait only, but the results have not yet been analysed. More comprehensive trials, both in the laboratory and in the field, will be carried out in 2016.

Alternative longline baits

Contact: Svein Løkkeborg (sveinl@imr.no)

The most common bait types (mackerel, herring, squid, saury) used by the Norwegian longline fleet are also used for human consumption. Bait prices have increased over the last years due to increased demand for marine food resources, and bait costs comprise a significant proportion of the total costs for the longline vessels. An initiative has therefore been taken by the industry to develop an alternative longline bait that is not based on resources used for human consumption. This collaborative project involves four commercial companies and two research institutes (Institute of Marine Research and Nofima Marin). The four companies are developing baits that will be tested in 2016.

SINTEF Fisheries and Aquaculture

Managing trawl catches by improving the hydrodynamic performance of sorting grid sections (Catch control II)

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The main objective of this project is to develop sorting grid section(s) (combined with a codend) for the Barents Sea demersal trawl fishery that provides high selective performance and good control over catch sizes even when exposed to extremely high catch rates. The experiments carried out in March 2015 with a 4-panel double Sort-V section in which the lifting panel was replaced by a grid. The sorting area of the new grid section was increase by 40% and the water flow measured inside the section was approx. 2.6 knots. The results did not significantly improve the selectivity of cod, haddock and redfish.

Development of biodegradable gillnets to reduce the effect of ghost fishing in Norwegian deep-sea gillnet fisheries (BIOgillnet)

Contact: eduardo.grimaldo@sintef.no

To date, Norway is the only country in the world that has a program for the systematic annual retrieving of lost, abandoned, discarded fishing gears (LADFG) from the most intensively fished areas. Since this program started the total number of retrieved gillnets has reached 18 300 nets (approx. 494 km). The retrieving operations are however highly demanding because of operation depth (500–1000 m), strong currents in the areas, and the uncertainties associated with the accuracy of the lost gear's position. In the last decade, a large number of R&D projects with biodegradable En-Pol gillnets to reduce the impact of ghost fishing have been carried out by Samsung Fine Chemicals Co. LTD and research institutions in Korea. These gears have been tested 13 different fisheries and shown similar fishing efficiency as gears made of synthetic fibres (nylon, polyethylene and polypropylene). This project brings together Korean and Norwegian institutions to develop biodegradable gillnets for the most important deep-water gillnet fisheries in Norway. The main objective is to develop biodegradable gillnets as a responsible fisheries management measure for reducing ghost fishing and pollution of plastics in the environment.

Deep-water tornado trolling for whitefish

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In this project a system for deep-water tornado trolling is being developed. This can be explained as a jig-/trolling line going continuously around in a closed loop from the vessel and through a stabilized, wide pulley hanging at a desired depth in a line from the vessel. The trolling line is automatically driven and shall be able to operate at depths down to 200 m and more to catch cod, haddock, and saithe.

Danish seine: Computer based design and operation

Contact: Bent Hermann (Bent.Herrmann@sintef.no)

The main objective of this project is to develop software tools for demersal seine fishing that ease future transition to the environmentally friendly Danish seine fishing method and that will support development of more optimized gear designs. The project have been finalized first quarter of 2016 and five scientific papers addressing different aspects of demersal fishing have been submitted to journals with peer review:

Herrmann, B., Larsen, R.B., Sistiaga, M., Madsen. N.A.H., Aarsæther, K.G., Grimaldo, E., Ingolfsson, O.A., 2015. Predicting Size Selection of Cod (Gadus morhua) in Square Mesh Codends for Demersal Seining: a Simulation-based Approach. In press. Fisheries Research.

Madsen, N.A.H., Aarsæther, K.G., Herrmann, B., Hansen, K., Jensen, J.H., 2016. The Physical Behavior of Seine Ropes for Evaluating Demersal Seine Fishing. Under review in Journal of Offshore Mechanics and Arctic Engineering.

Herrmann, B., Krag, L.A., Feekings, J., Noack, T., 2016. Understanding and predicting size selection in diamond mesh codends for Danish seining: a study based on sea trials and computer simulations. Accepted for publication in Marine and Coastal Fisheries Journal.

Notti, E., Brčić, J., De Carlo, F., Herrmann, B., Lucchetti, A., Virgili, M., Sala, A., 2016. Assessment of the relative catch performance of a surrounding net without the purse line as an alternative to a traditional boat seine in small-scale fisheries. Marine and Coastal Fisheries, Vol. 8, pages 81-91.

Madsen, N.A.H., Aarsæther, K.G., Herrmann, B., 2016. Predicting the effect of seine rope lay-out pattern and haul-in procedure on the effectiveness of demersal seine fishing: A computer simulation-based approach. Under review at PlosOne.

Effect of trawl and codend construction on the filet quality of cod (Gadus morhua) and haddock (Melanogrammus aeglefinus)

Contact: Manu Sistiaga (Manu.Sistiaga@sintef.no)

The objective in this project is to evaluate the potential for improvement on fish quality obtained by modifying the trawl constructions used in the Barents Sea today. The investigation aims at clarifying if changing from two-panel constructions to four-panel constructions and using knotless materials can reduce the presence of bruises in fish filet.

The quality of the fish delivered by a vessel depends on the initial quality of the fish taken onboard. Many trawlers in the Barents have reported problems and substantial economical loses due to lower quality on the fish delivered. Thus, getting rid of blood marks or bruises created by the gear during the fishing and hauling operations is of special interest for the fleet.

In the project we aim at answering the following questions:

- Is the quality of fish caught with trawls constructed in four panels better that that of the fish caught with trawls constructed in two panels?
- Does the use of knotless codends reduce the amount of bruises or blood marks in fish filet? Should this type of netting also be used in the extension piece and grid section?
- Does the use of newly designed gentle codends give quality wise any advantage compared to traditional codend designs?

How many fish need to be measured in trawl selectivity studies?

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The aim of this study is to provide practitioners working with trawl selectivity with general and easily understandable guidelines regarding the fish sampling effort necessary during sea trials. Particularly, we wanted to provide guidelines on the number of fish necessary to catch and length measure in a trawl haul in order to assess the selectivity parameters within an intended maximum uncertainty level. In addition, the study investigated the dependence of this uncertainty level on the experimental method applied for the data collection and on the potential effects of factors like the size structure in the catch relative to the size selection of the gear. We based the study on simulated data created from two different fisheries: the Barents Sea cod trawl fishery and the Mediterranean Sea multispecies trawl fishery represented by the red mullet. The purpose of using these two completely different fisheries was to obtain results that can be used as general guidelines also for other fisheries. The results showed that the uncertainty in the selection parameters decreased with increasing number of fish measured and that this relationship could be described by a power model. The sampling effort needed to achieve a specific uncertainty level for the selection parameters L50 and SR was always lowest for the covered codend when compared to the paired-gear method. In many cases, we observed that to keep a specific uncertainty level the amount of fish needed to measure with the paired-gear method is around 10 times higher than with the covered codend method. The trends observed for the effect of sampling effort in the two fishery cases investigated were similar. A scientific paper has been submitted: Herrmann, B., Sistiaga, M., Santos, J., Sala, A., 2016. How many fish need to be measured to effectively evaluate trawl selectivity? Under review at PlosOne.

Estimation of the effect of gear design changes in catch efficiency: methodology and a case study for a Spanish longline fishery targeting hake (Merluccius merluccius)

Contact: Bent.Herrmann@sintef.no, Lasse.Rindahl@sintef.no, Manu.Sistiaga@sintef.no, Ivan.Tatone@UiT.no

We outline a method to estimate the relative catch efficiency of different fishing gear designs based on comparing catch data. The method described does not require equal number of deployments or alternation between the gears to be compared, and accounts for multiple competing models describing the data by using multi-model inference. Further by applying a double bootstrapping procedure the method accounts both for the uncertainty in the estimation resulting from between deployment variation in catch efficiency and availability of fish, and the uncertainty on the size structure of the catch for the individual deployments. Finally, incorporating the multi-model inference into each conducted bootstrap the method also accounts for the uncertainty due to uncertainty in model selection. Using the outlined method we investigated the effect of gear design changes in catch efficiency for a Spanish longline fishery targeting hake (*Merluccius merluccius*). We tested and compared four different designs against the traditional design applied in the fishery; a new automatized design that differed in hook size, snood line length and snood line diameter, and three designs where only one of the parameters was changed at the time. The new design is favourable for the Spanish demersal hake fishery because the deploying and hauling processes are automatized, meaning that the manpower needed to conduct the fishery would be decreased. However, this study demonstrates that adopting the new automatized design results in a significant decrease in catch efficiency. The analysis conducted revealed that the reduction in catch efficiency was consequence of the thicker snood line applied in the new design. The change in hook type and snood line length used had no effect in the efficiency of the fishery. A scientific paper has been submitted: Herrmann, B., Rindahl, L., Sistiaga, M., Tatone, I., 2015. Estimation of the effect of gear design changes in catch efficiency: methodology and a case study for a Spanish longline fishery targeting hake (*Merluccius merluccius*). Under review at Fisheries Research.

The Arctic University of Norway UIT

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Contact: Roger B. Larsen (roger.larsen@uit.no)

During 2015 we participated in several projects on trawls and pot fisheries (and management) for snow crab led by the SINTEF fisheries and aquaculture (and IMR). These projects will be reported by SINTEF F&A (and IMR).

Snow crab (Chionoecetes opilio) interactions with bottom trawls and possible conflicts between trawl fleets and pot fisheries in the Northeast Barents Sea.

MSc Student Allison Luettel.

Contact: Roger B. Larsen (roger.larsen@uit.no)

Approximately two decades ago, snow crab (*Chionoecetes opilio*) were discovered in the Barents Sea. The areas in which they have come to establish themselves, in many instances, overlaps with areas trawled by the commercial groundfish fleet, consequently, leading to interactions between snow crab and bottom gear. Snow crabs, which after settling to the bottom go through a series of moults in order to reach maturity. During this period, they are particularly vulnerable, especially in an area like the Barents Sea, which has a year-round bottom fishery.

The aim of this study is to look at the interactions taking place between *C. opilio* and the groundrope used in the traditional commercial fleet, by conducting direct in situ video observations of the encounters to examine the crab's behaviour. In addition to behaviour, snow crab injuries were recorded in order to determine, what, if any factors might influence injury(s) sustained during interaction with the mobile gear. This experiment employed a modified two-panel version of an Alfredo No. 3 trawl with a retainer bag affixed underneath the centre section of the gear to sample snow crabs that escaped below the central section of the trawl.

A study on the escape rate of Northeast Atlantic cod (Gadus morhua) and haddock (Melanogrammus aeglefinus) under the fishing line with two different groundropes in the Barents Sea bottom-trawl fishery

MSc Student Jesse Brinkhof.

Contact: Roger B. Larsen (roger.larsen@uit.no)

The aim of this study was to investigate the escapement under the fishing line for cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*) with the conventional rock-hopper gear and a new type of gear termed semi-circular spreading gear (SCSG). The trials were conducted during November 2014 and February 2015 in the Barents Sea under varying environmental conditions. In order to catch the escapees a retainer bag was attached to the fishing line of the trawl. Multi model averaging was applied for calculating the efficiency, i.e. escapement rate for all length groups. A highly significant difference in the rate of escapement between the two types of groundgears was found. Summarized for all length groups above 65 cm, 14% of the cod escaped under the fishing line of the rock-hopper gear, and 5% under the SCSG during the trials in November 2014. This resulted in an efficiency improvement of 11%, and escapement reduction of 67%. In February 2015 the escapement was 5% for the rock-hopper, and 2% for the SCSG, resulting in an efficiency improvement of 3%, and an escapement reduction of 57%. The overall improvement of efficiency for cod is thus 8%, and a reduction in escapement of 63%. The escapement of haddock for all lengths above 62 cm was estimated to 7% for the rock-hopper gear, and 1% for the SCSG, implying an efficiency improvement of 6%, and an escapement reduction of 85%. Based on the present data no correlation was found between the rate of escapement and fish density, ambient light intensity, nor artificial light. However, a positive correlation was obtained between temperature and the escapement rate for some length groups.

Over the recent years the tendency in the bottom-trawl fisheries has been increasing the trawl dimension in order to increase efficiency, with subsequent increase in fuel consumption and emission, as well as possibly increased negative bottom impact. The demonstrated improvement of the SCSG compared to the conventional rock-hopper gear entails multiple advantages such as increased efficiency due to reduced escapement, reduced fuel consumption and emission, and reduced negative bottom impact. By introducing a more efficient groundgear this study provides an improvement from the current situation that is believed to be of importance both from fisheries and environmental point of view, as well as for the accuracy of the trawl surveys for stock assessment purpose.

Initial Norwegian trials with LED lights on shrimp trawls to improve bycatch reduction

Contact: Roger B. Larsen (roger.larsen@uit.no)

Currently, there is a great interest in improving bycatch reduction in the Norwegian shrimp fisheries and joint efforts by the fishing fleet, the Fisheries Directorate and science started recently. The aim is to reduce bycatch well below today's strict regulations on legal numbers of fish counted as bycatch.

Despite the compulsory Nordmøre grate (since 1991/1993) removes large quantities of fish during shrimp trawling, the 19.0 mm bar distance allow small juveniles and slim fish in general to enter the codend, i.e. part of the retained catch. Typically juveniles smaller than 15-16 cm from important species such as cod, haddock, redfish are likely to be retained whenever they occur along the fishing ground.

We were encouraged by the convincing results reported by Bob Hannah and Steve Jones from the Oregon shrimp fishery in August 2014. During trials in February, May and December 2015 we tried to mimic their setup with green Lindgren-Pitman Electralume LED lamps along the fishing line. We attached 16 (and 20) of these LED lamps along the fishing line. In these tests we got only small shrimp catches and rather few retained fish. The results show some reduction on the bycatch of some juvenile groundfish, but not for all species and with large variation. The LED light seems to reduce the shrimp catches too an unacceptable level for fishers. The results were reported to the Directorate of Fisheries February 2015.

Bycatch reduction in the North-East Atlantic shrimp fisheries

Contact: Roger B. Larsen (roger.larsen@uit.no)

Currently, there is a great interest in improving bycatch reduction in the Norwegian shrimp fisheries and joint efforts by the fishing fleet, the Fisheries Directorate and science started recently. The aim is to reduce bycatch well below today's strict regulations on legal numbers of fish counted as bycatch.

At the Arctic University of Norway we have initiated a set of experiments to document the effect on various bycatch species and sizes (including shrimps below minimum landing size). In these trials we implement new installation procedures for the compulsory Nordmøre grid, new guiding panel installation, we examine the effects of square mesh panels in the codend, extra sorting grids and various stimulators. Some of the results will be presented at the FTFB WG meeting, April 2016.

Snow crab in the North-East Atlantic – a possible conflict between crab potting and established trawling for groundfish and shrimp

Contact: Roger B. Larsen (roger.larsen@uit.no)

Currently, there is a great interest in mapping the distribution and demography of the invasive snow crab (*Chionoecetes opilio*). At the Arctic University of Norway we participate with three research institutes to collect data by ordinary and modified crab pots and bottom trawls. During our fish and shrimp trawl studies in the North East Atlantic we have over the last years added bags behind the fishing line to collect escapees (fish and crabs). Since November 2015 we used a re-designed version of these bags and improved the catchability of them. More than 2000 snow crabs of sizes

12-148 mm carapace width were collected with “retainer bags” during a week in February this year.

The data will also be used to examine if bottom trawling will cause damage on the snow crab and to describe how a new type of fishery evolves in an area where trawling for shrimps and trawling (and longlining and demersal seining) for fish is established.

11.10 The Netherlands

IMARES

Project: ICES research on pulse trawling

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

ICES WGELECTRA met in IJmuiden, the Netherlands on 10–12 November 2015 to review knowledge of the effects of electrical fishing on the marine environment (a), evaluate the effect of a wide introduction of electric fishing (b), conduct a pilot study on control and enforcement procedures for flatfish pulse trawling (c), evaluate the impacts of restrictions on pulse characteristics for shrimp pulse trawling and groundrope configurations (d), to make an inventory of views on pulse fishing among various stake-holders in European member states (e), and respond to a request by France for ICES to review the work of the Study Group on Electrical Trawling (SGELECTRA) and IMARES and to provide an updated advice on the ecosystem effects of the pulse trawl, and especially on the lesions associated and mortality for targeted and non-targeted species that contact or are exposed to the gear but are not retained on board, and with special reference to those species covered by the on Natura 2000 species and habitats Directives (f). Reports are on the ICES website (www.ices.dk).

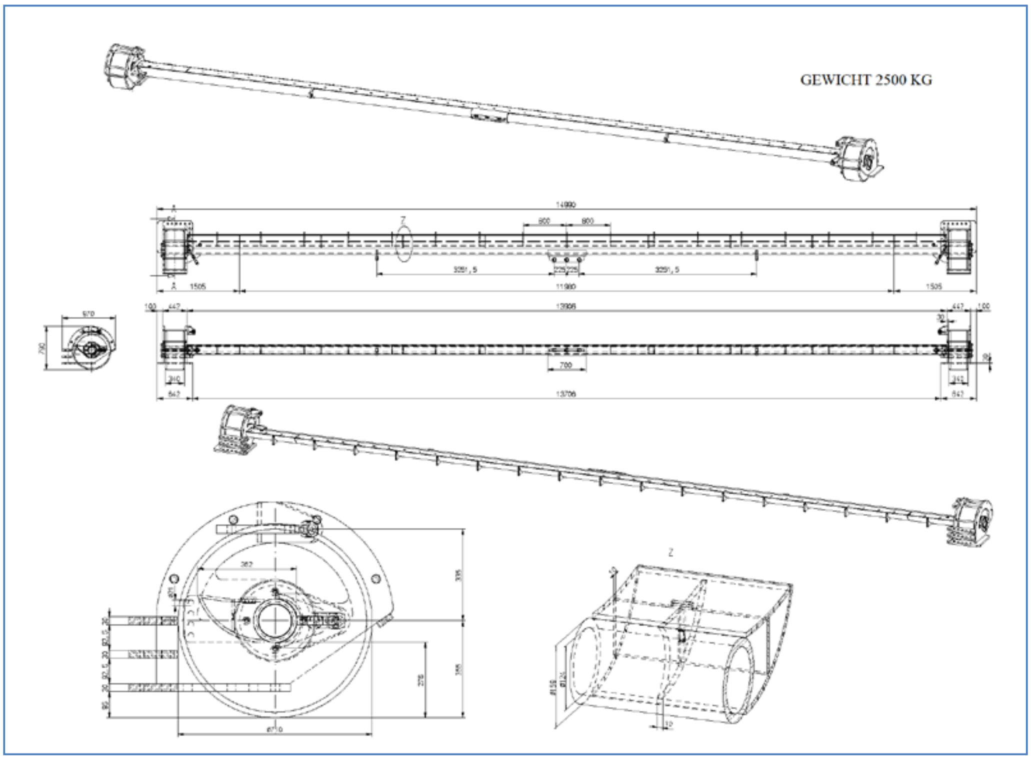
A project was finished to define the research agenda in brown shrimp (*Crangon crangon* L.) pulse trawling in close collaboration with ILVO-Fishery of Ostend, Belgium, and representatives of the Ministry of Economic Affairs, NGO’s and the fishing industry.

Two new projects were continued on the problem of control and enforcement in pulse trawling on flatfish and brown shrimps. The idea is to build a system monitoring the electrical performance of a pulse fishing gear and storing data over a prescribed time interval and making these data accessible to inspection services and run a pilot with inspections at sea. For flatfish pulse trawling a revised set of regulations was suggested to allow inspections by control agencies. The idea was to also give a limit for the peak voltage between electrodes. For shrimp pulse fishing a research programme was made up for the existing four Dutch vessels working with the technique.

Project: VIP HydroRig-II

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

A new model HydroRig-II was designed built and tested in 2014. The design was based on a wider beam (15 m), for which a derogation was asked, and wheels instead of trawl shoes. In June 2014 a small UW camera was used for direct observations. The catch results on plaice using 100+ mm mesh size were relatively good (+10-15%) compared to other vessels in the neighbourhood with initially a rising trend over the duration of the trials, but due to the larger size of the gear the drag reduction was lower (~ 10%) than with the first prototype. The results on sole with 80 mm mesh were not better, and gear drag the same as for the conventional gear. A detailed catch comparison was unfortunately not carried out. The project was terminated with a final report.



Engineering drawing of HydroRig II by VCU-TCD Ltd. Urk, the Netherlands.

Video footage by Geertruida Ltd. Urk, the Netherlands.

Project: VIP VRV

Contacts: Bob van Marlen (bob.vanmarlen@wur.nl); Jeroen Kals (jeroen.kals@wur.nl); Marnix Poelman (marnix.poelman@wur.nl)

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. At current market conditions plaice by-products were estimated to bring a price of 200 €/MT during autumn, and less than 150 €/MT in spring. This is still lower than the 500 €/MT the fishing company estimated to make a profit. Higher prices could be obtained by making bioactive peptides through hydrolysis. Tests showed potential for DPPH-I inhibition when using fish offal and adding enzymes Alcalase or Newlase F in this process.

Project: Survival of discard fish and how to improve it

Contacts: Bob van Marlen (bob.vanmarlen@wur.nl); Pieke Molenaar (pieke.molenaar@wur.nl); Karin van der Reijden (karin.vanderreijden@wur.nl).

In the light of the landing obligation, the chances of survival of sole, plaice and dab discards in the Dutch demersal fisheries were studied. One of the objectives was to determine the average survival rate of sole, plaice and dab discards in commercial pulse and twin-rig fisheries of the Dutch fleet. This was executed by monitoring fish collected from catches for a certain period of time (21 days on average) to observe fisheries-induced mortality. A second goal of this study was to investigate whether a vitality score can be used as a proxy of the survival chance. The vitality of each fish was assessed individually by scoring external damages and the impairment of reflexes, and related to the observed survival time. A third goal was to study the variation in discard survival estimates by looking into correlations between survival estimates and environmental or other potential factors. Finally, (goal 4), it was investigated whether adjustments in the processing line on-board of the participating vessels can lead to higher survival of sole, plaice and dab discard.

In total eleven experimental trips were carried out on-board three different vessels in the North Sea in the period between November 2014 – October 2015. Live fish from the catch were collected from different locations in the processing line and at different times. All sampled fish were scored for external damages and reflex impairment, then tagged to allow individual monitoring over time. To observe and record the survival times, these fish were stored in a specially developed system of tanks filled with continuously refreshed seawater. Except for the first trip, all experimental trips were done with three of such tank systems. The tank systems were designed with restrictions in dimensions and weight to allow transport from the vessels to the laboratory in Yerseke, the Netherlands and monitor survival over an extended period of time. During research trips fresh seawater was continuously supplied to the tank systems. During transportation water circulation was maintained and to ensure sufficient oxygen air was supplied. Fish status was checked and dead fish were removed daily during the monitoring period of some three weeks. To distinguish between fisheries-induced mortality and handling-induced mortality, control fish were used. These control fish were caught using a small vessel operating a shrimp trawl in short tows at low speed. These controls were collected 4 weeks before the survival experiments and were treated in exactly the same way as fish from the catch.

Overall the survival rates of discard sole (as determined after a monitoring period of 21 days on average) on the vessels fishing with a pulsewing (12 m width) and a commercial towing duration (~ 125 minutes) varied between 8% and 48%, with an average of 31% over all trips. For short hauls (~ 60 minutes) the overall survival rate was higher (24%–59%) with an average of 41%. The overall survival rates of discard plaice on the same pulse vessels taken from commercial hauls of ~2 hours varied between 4% and 28% per trip with an average of 16%. Using a short tow duration (~60 minutes) increased this percentage, w ith an average of 39%. Dab was only sampled during one trip on-board a pulse vessel, so this dataset is very limited. The overall survival rate of discard dab in this trip was 15%. In the twinrig fisheries, the overall survival rate of discard plaice was investigated in two trips, with 10% survival on average (5% and 16% per trip). Dab was sampled once in the twinrig fisheries, with an overall survival estimate of 8%.

Sole control fish showed good survival rates (~ 85%) in our experiment. Plaice controls suffered mortality a couple of days after arrival at the laboratory in Yerseke, around day 12. Mortality of control fish is undesirable and may lead to discussions about the accuracy and reliability of the observed survival rates. After trip eight, a *Vibrio* infection in the tank system affected mortality in the control and experimental fish. However, by right-censuring these data, possible infection effects are excluded.

The study showed that the overall discard survival rates are correlated with fish vitality. Vitality was measured in two distinct ways; by using a damage classification of A, B, C, and D, comparable with earlier survival research and as a summation of present damage scores and reflex impairment scores, divided by the total number scored damages and reflexes. Both showed a relation with the survival rate of discard plaice. Too few data were available for dab and sole to find a good correlation. However, the data suggest that a similar relation exists for sole discard survival. To confirm this relation, more data should be collected, in which external factors are taken into account.

The overall discard survival rate varied considerably between the trips, however, the conditions also varied to a great extent between trips. It should be noted that a full factorial design, in which all (potential) factors are tested individually was not made for this study. Such a design was practically not feasible, as multiple factors could not be controlled (such as weather), while other factors are very coherent (such as fishing location and fishing depth), and because of limitations in resources only a relatively small number of trips could be carried out. As a result only a first explorative analysis was done to identify potential, influential factors. From this explorative analysis, it seems that water temperature, towing duration, fishing depth and vessel are factors that are highly correlated with discard survival rates, but a full predictive model was not tested so far. Such a model could lead to better knowledge of the various factors causing the mortality of the fish, and hence, give insight in adjustments that will increase discard survival rates.

Five experimental trips were done with one adjusted deck hopper to be compared to a conventional one, for which one vessel was sampled once and the other vessels were both sampled twice. Each vessel had a unique, new deck hopper installed onboard. Each hopper was developed by a particular company, however, the designs were based on a shared principle. The new design allowed fishers to empty the nets in a hopper with ample seawater, and air and/or seawater (and thus oxygen) supply. It was studied whether these adjustments would lead to higher overall discard survival rates. Based on these five trips, it seems that this is indeed the case. However, the observed discard survival in the adjusted hoppers varied widely. One of the trips was done in bad weather conditions and on the other hand the survival monitoring in the laboratory of two trips was aborted due to a *Vibrio*-infection. Definite conclusions about potential higher discard survival estimates can therefore not being made yet.

The new deck hoppers should be (self) sampled for more trips, under various circumstances, to determine actual increase of discard survival rates.

New fish holding tank units used in survival experiments.

New deck hopper on-board GO31. Left: Stone catcher. Right: System to maintain and adjust water level in hopper.

Project: Net innovation in pelagic fisheries

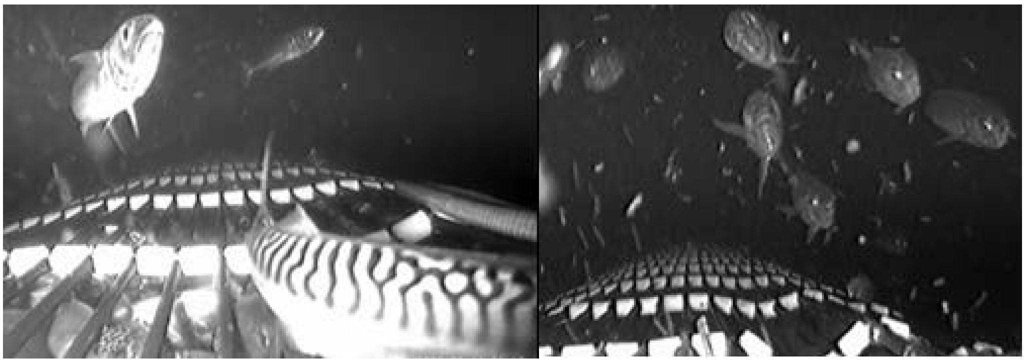
Contacts: Harriët van Overzee (harriet.vanoverzee@wur.nl); Edwin van Helmond (edwin.vanhelmond@wur.nl); Bob van Marlen (bob.vanmarlen@wur.nl)

In response to the landing obligation for pelagic species that started in 2015 the Dutch pelagic fishing industry has tested sorting grids with the aim to avoid the capture of undersized and/or unwanted fish.

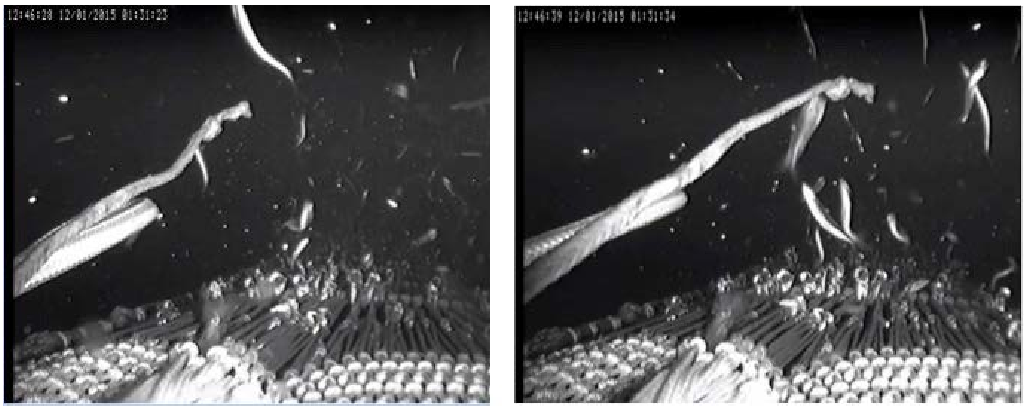
Data on catches were collected through a self-sampling programme. Crewmembers on board three large freezer trawlers of the Dutch Pelagic Freezer-trawler Association ("Jan Maria" (BX791), "Willem van der Zwan" (SCH302), and "Carolien" (SCH81)) collected data during trips fishing with their standard gears and a range of sorting grids. Overall, six trips were included in the analysis. In these six trips a modified net was used during 11 hauls (~ 9% of all hauls in these trips) in 2014 and 12 hauls (~ 5% of all hauls in these trips) in 2015.

In order to determine whether a grid is effective in letting small individuals escape, we hypothesized that the fraction of smaller fish in the catch when fishing with grids is smaller than the fraction of smaller fish in the catch when fishing without grid. Statistical tests were used to determine whether an association, between the fraction small fish caught and the usage of a sorting grid, exists. The number of hauls where grids were used was relatively small (23 hauls out of a total of 352 hauls). Analyses were conducted for horse mackerel (*Trachurus trachurus* L.) and mackerel (*Scomber scombrus* L.). The effect of grids for both species was found to be not statistically significant.

An analysis was also done on video footage identifying species that managed to escape through the grid. Length frequency distributions for mackerel and horse mackerel were constructed based on length estimations from the video footage. The accuracy of estimated lengths vary between 10 and 50 mm, and the percentages escaped between 3.4–7.9% for mackerel, and between 0.2–0.5% for horse mackerel. Underwater observations during two hauls showed no escapees of boarfish (*Capros aper* L.), indicating that this species did not escape through the grid. Direct observation with video recording of fish behaviour in proximity of the grids in combination with catch data analysis seems to be a better methodology for future research. In future it is recommended to make an attempt to increase the number of experimental hauls. The relatively small dataset made it difficult to draw conclusions from the statistical analyses.



UW video footage by Maritiem Ltd. Katwijk, the Netherlands showing fish species identified during video analysis: mackerel (top left), horse mackerel (top right).



UW video footage by Maritiem Ltd. Katwijk, the Netherlands showing escapement of blue whiting.

Project: Net innovation in demersal fisheries

Contacts: Pieke Molenaar (pieke.molenaar@wur.nl); Bob van Marlen (bob.vanmarlen@wur.nl)

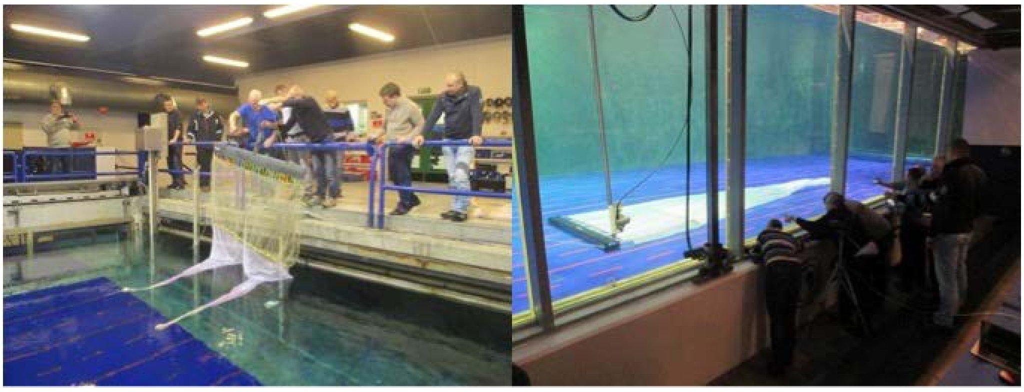
This project was initiated by the Dutch cooperation "Coöperatieve Visserij Organisatie (CVO)" to enhance gear selectivity and release as many undersized fish as possible as a reaction to the EU Landing Obligation on discards.

A group of skippers, netmakers, and (pulse)wing developers went to the Hirtshals flume tank of SINTEF in January 2015 to study a range of selective devices at model scale. At present, skippers of various vessels work on testing new devices. Following the design phase a number of gear configurations were tied out on various commercial pulse trawlers, a beam trawler (that later was converted to pulse trawling), and twin-riggers. Initial tests were done using self-sampling protocols, in many cases followed up by a detailed catch comparison with IMARES scientists on-board.

The trials on the beam trawler gave an indication of a reduction in fish discards, but the penalty was a loss in marketable sole. In the pulse gears a horizontal separator panel with two codends, one above the other was tested, resulting in a fish discards reduction between 15 and 35%, comparable to earlier findings. It appeared that when applying this configuration, some 10% of sole turned up in the upper bag, which would get lost when the mesh size of the upper bag would be increased (this was the idea to release undersized fish). In the twin-rigs a fish discards reduction between 30 to 35% was found, but these results were not very accurate, due to sampling problems.

Summary of trials and configurations

Gear	Mesh-size [mm]	Target-species	Ship	Tested net configurations
Beam trawl	80	SOL, PLE	UK45	Separator panel with 2 codends and escape panel in upper side.
Pulse trawl	80	SOL, PLE	TX68	Separator panel leading upwards and escape panel in upper side.
Pulse Wing	80	SOL, PLE	UK45	Square mesh codend, separator panel and escape panel in upper side, and T45 side panels with larger meshes.
			TX36 TX36	Sole separator panel and escape panel. Separator panel with 2 codends.
			ARM22	Separator panel and escape panel in upper side and 2 codends.
			ARM22	Vertical separator panel with inner codend.
Twin-rig	+100	PLE	OD6	Escape panel in upper side.
			GY57	T90 meshes in 120 mm codend.



Pictures by Pieke Molenaar (IMARES) Model tests SINTEF flume tank Hirtshals, Denmark, 19/01/2015.

Project: Selective twin-rig on flatfish

Contact: Bob van Marlen (bob.vanmarlen@wur.nl), Pieke Molenaar (pieke.molenaar@wur.nl)

Fishing company Snoek Ltd. of Urk, the Netherlands tested a new design twin-rig to fish more selectively on plaice and release undersized fish in anticipation to the EU Landing Obligation. The new net was fitted with a guiding panel made of 80 mm square mesh connected to a horizontal panel of 160 mm square mesh leading to an escape hole.

A detailed catch comparison was made in week 49 van 2015 resulting in 12 hauls. The new net did not catch fewer discard fish, benthos and debris.

A second objective was to adapt the fish processing line on-board MFV SC25 "Evert Snoek'' to increase discard survival. In week 50 damage classes and scores were compared between a new design of deck hopper (with additional water and air supply) and a conventional deck hopper. No significant differences were found however.

A third approach in this project was to automate part of the fish processing by installing a robot arm able to distringuish between species (dab, plaice, lemon sole, other), and pick fish from the conveyor belt and place them in separate spots depending on species. This device was demonstrated in December 2015 and worked well, but further debelopment for use on a moving vessel still has to be done. The system shows potential to speed up the process of fish selection, providing that fish is fed on the conveyor belt one by one.

Model in de SINTEF flumetank in Hirtshals in January 2015.

New deck hopper with water and air supply on-board SC25 (left). The water level in the hopper is controlled by using hydraulic slides (right).

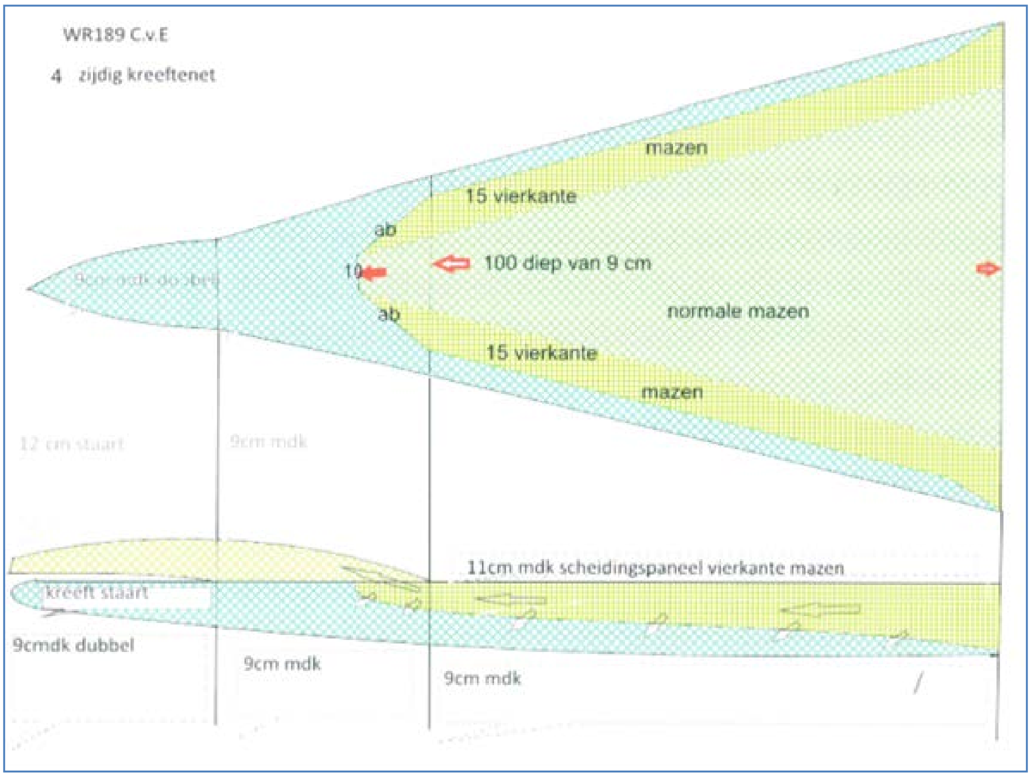
Project: Selective Nephrops trawl

Contact: Pieke Molenaar (pieke.molenaar@wur.nl), Josien Steenbergen (josien.steenbergen@wur.nl)

The aim of the project was to develop a highly selective *Nephrops* trawl for the small Dutch vessels < 300 hp. Half of the landings are fish bycatch and therefore is an important source of income. The Nephrops trawl should be made selective for larger fish species without loss of marketable Nephrops. Trawl modifications were first monitored by self-sampling. If the self-sampling results were promising a scientist joined a trip and monitored the catch composition on-board.

In 2014 and 2015 6 innovative trawl designs were tested with combinations of escape panels, separation panels and/or grids on board of 6 commercial Nephrops trawlers. One scale model was tested in the SINTEF flume tank in Hirsthals, Denmark in January 2015.

The most successful trawl (SepNep) is designed to separate fish and Nephrops by a 110 mm separation panel with diamond and T45 meshes. Fish and Nephrops are collected in different codends: a 80mm codend for Nephrops and a 120 mm codend for (flat)fish. Selfsampling showed a very large reduction in discards, therefore a scientific research trip was carried out in May 2015. Compared to a conventional trawl the total amount of discards in the catch was reduced by 65% ($p = < 0.001$) by using a SepNep. For undersized plaice a 69% reduction was observed and for dab 78%. Although the trawl design is successful in reducing discards, a loss of 21% marketable Nephrops was found during the research trip. Netmakers have been working on reducing this loss and claimed a certain level of success, and more work will be done during the Nephrops season in 2016.



Working principle of the SepNep trawl.

SepNep trawl during production in the net loft.

Project: Reduction of discards in shrimp trawling "the letterbox"

Contact: Diana Slijkerman (diana.slijkerman@wur.nl), Pieke Molenaar (pieke.molenaar@wur.nl), Michiel Dammers (michiel.dammers@wur.nl)

In this project the "letterbox" is studied as an alternative for the sieve net or veil for the Dutch brown shrimp beam trawl fisheries. This alternative should be used during months when seaweed is abundant and clogging of the meshes in the sieve net is problematic. In addition to experiments with the letterbox trials are done with larger mesh sizes. Two vessels are involved in mesh size trials and ten vessels are involved in data collection and observer trips using the letterbox.

Shrimp trawl with letterbox, viewing aft.

Letterbox

From April to October 2015, 18 observer trips and 55 self-sampling trips (independent research by fishers) were conducted in the North Sea and Wadden Sea to test the letterbox.

- More fish and benthos (based on weight) were caught in the "letterbox" trawl compared to the trawl with a sieve net (or veil). This difference was larger in the North Sea than in the Wadden Sea
- In the North Sea shrimp landings were higher in the letterbox trawl.
- The average length of flatfish was larger in the "letterbox" trawl but less juvenile flatfish (plaice, dab, sole, flounder) were caught.
- A total of 57 species of fish and benthos were caught, from which 14 species (25%) significantly more in the letterbox trawl. In the North Sea the catch of 19% of the 54 species was significantly higher.
- The highest quantities of seaweed and algae were caught during the months July and August 2015. No difference in catch was observed between the letterbox trawl or sieve net trawl were observed in this period.

The letterbox is less effective in reducing unwanted bycatch compared with the sieve or veil. Based on the total catch, the letterbox caught more fish and benthos than the sieve veil trawl.

Larger mesh sizes

From December 2015 to October 2015 two different codend mesh sizes were tested on two brown shrimp vessels, a conventional 19.5 mm against the larger mesh size: 24.4 and 21.1 mm (between knots). A total of 69 valid hauls from self-sampling trips and 49 valid hauls of observer trips were used in the data analysis. A mesh size of 24.4

mm is effective to keep the same amount of shrimp landings (in some cases even more shrimp landings) and reduce the total catch and shrimp bycatch. A mesh size of 21.1 mm gives the same results, however these differences are very small.

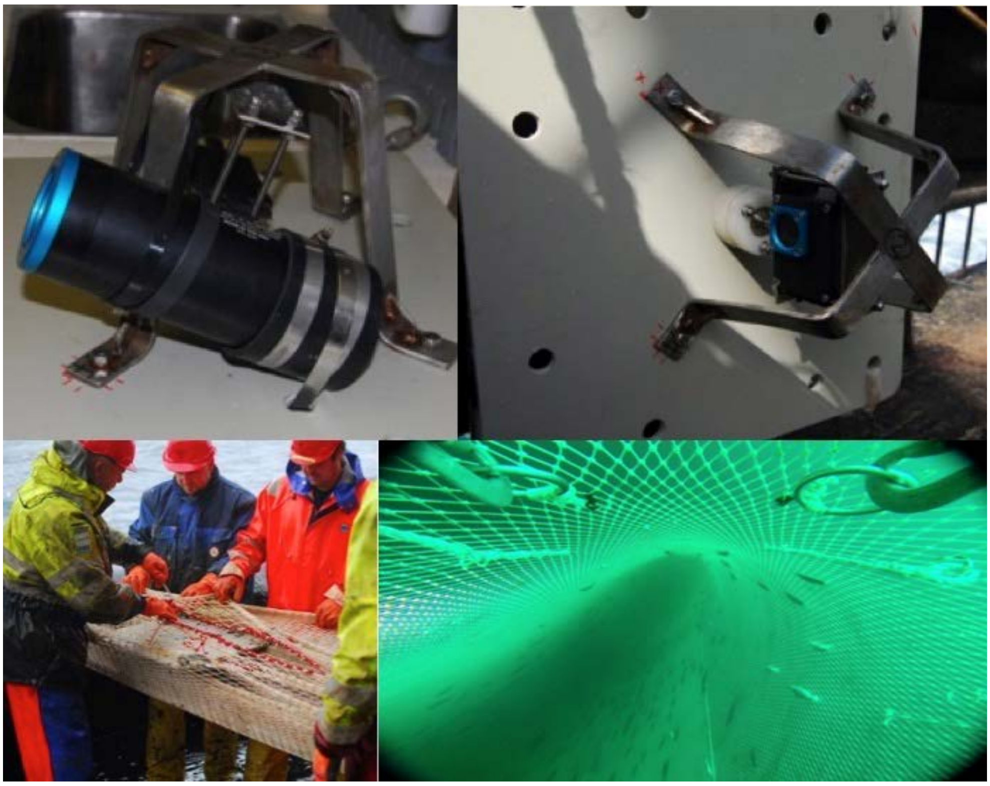
Project: Ecosystem Acoustics

Contacts: Sascha Fässler (sascha.fassler@wur.nl); Dirk Burggraaf (dirk.burggraaf@wur.nl)

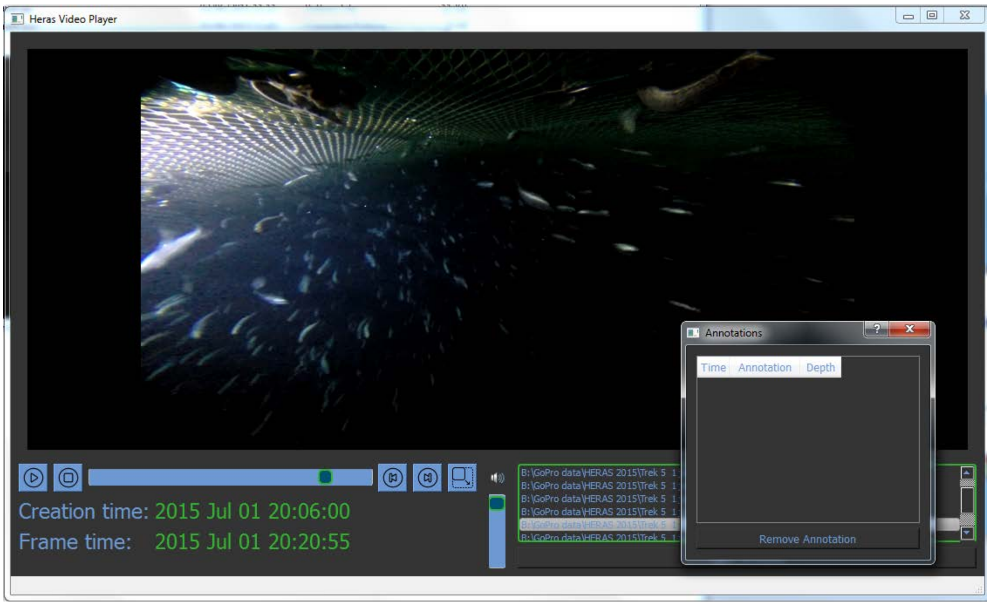
Monitoring of the pelagic ecosystem is a key component of the statutory survey programmes in the EU to deliver annual data underpinning policy drivers such as MSFD, CFP and DCF. The project aims to further develop acoustic ecosystem monitoring techniques (acoustic-optical). Therefore, it will keep the methods at the most current state and explore alternative ways to apply new and upcoming techniques.

With the shift in survey focus towards an ecosystem approach, data collected on acoustic surveys needs to be supplemented with standard and complementary sensors to improve monitoring and classification of (many more) species. There are higher demands on the interpretation of acoustic data and a low-cost optical systems as proposed here could be used to give valuable additional information about when, where, and how much is sampled by the trawl when verifying (ground-truthing) acoustic observations.

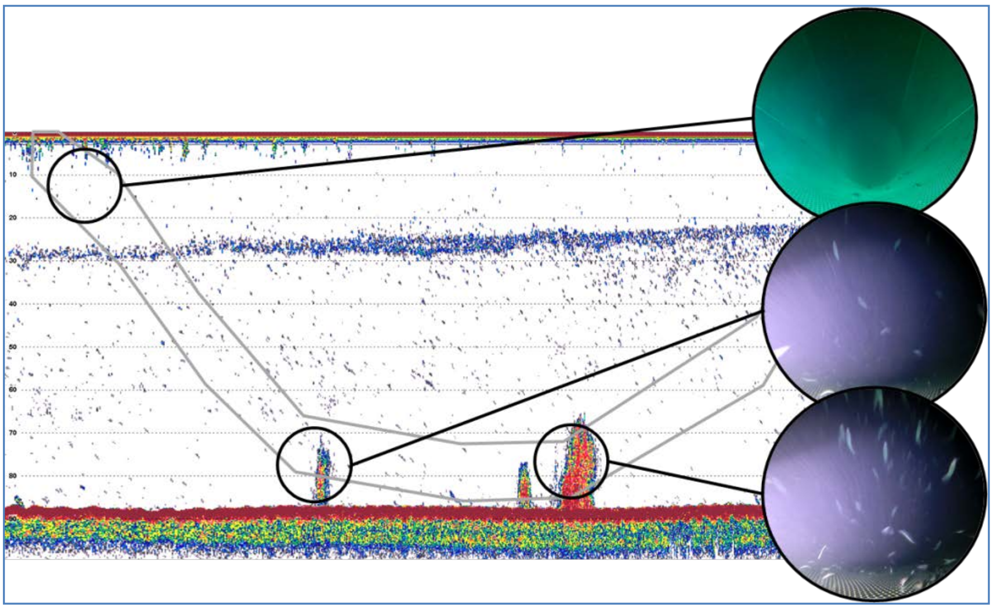
The acoustic-optical net camera sampling system that was started off previously will be further developed and be used during pelagic ecosystem surveys for improved ecosystem characterization.



Impressions of the GoPro net camera system



Software to process and annotate GoPro net camera footage.



Net camera concept description to link acoustic observations with biological sampling.

Project: KB Towards a better understanding of fishers' behaviour

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Under the Knowledge base fund of IMARES, we have been granted money for our project *Towards a better understanding of Fishers' Behaviour*. The project aims at developing a new transdisciplinary theoretical framework on fishers' behaviour and will develop new ways of collecting and analysing data of fishers' behaviour. The rational for the project is that successful fisheries management requires a thorough understanding of "fishers' behaviour", the collective set of decisions made every day on board of fishing vessels. Sudden and drastic changes in fisheries management, as e.g. in the case of the current implementation of the European landing obligation, poses the challenge whether our current knowledge of fishers' behaviour is sufficient to forecast changes in fisheries. There is general consensus that it is unclear how fishers will respond to new rules and regulations.

Fisheries behaviour research in fisheries science is predominantly done by natural scientists and economists. Mostly by assessing available catch and effort data and by modelling. Fisheries behaviour currently is thus approached by *inferring* human behaviour from statistics. From recent projects (CCTV, displacement, landing obligation) we have learned that our current research approaches can be strengthened by making use of social science methods (interviewing, focused group discussions). This 'add-on' approach can however be taken a step further by fully integrating the methods and by building a new theoretical framework of understanding fisheries behaviour. A more systematic collection of qualitative data on fishers' behaviour may improve our understanding and improve forecasts of the response of fishing fleets to changing policy. We will write a paper reviewing different approaches to understanding fishers' behaviour from the different sciences (biology, economy and social science) and we will revisit our data collection program and see whether changes can be made to collect more data.

Project: Pulse trawl impact assessment

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According to the EU legislation it is forbidden to fish with explosives, poison and electricity. Nevertheless, about 80 commercial beam trawlers are currently using an electrical pulse trawl to catch flatfish in the North Sea. The pulse trawl is a promising alternative for the traditional beam trawl, which uses heavy chains to chase the flatfish out of the seabed and has substantial collateral damage to the ecosystem. The pulse trawl is a promising alternative to reduce the mechanical disturbance of the seabed, CO2 emissions and fuel cost. On the other hand, it is unknown whether electricity may have negative effects on marine organisms and the benthic ecosystem.

The ministry of Economic Affairs of the Netherlands has commissioned a 4-year research project (2016-2019) to provide a sound scientific basis for the assessment of the effects of pulse trawling. The project is carried out by a consortium led by IMARES (IJmuiden, Netherlands). Other consortium partners are: Experimental Zoology Group of Wageningen University (Netherlands); Benthic ecology group of NIOZ (Yerseke, Texel, Netherlands); and the Fisheries Research Institute of Belgium (ILVO, Oostende, Belgium).

The overall aim of this project is to assess the long-term impact of the commercial application of pulse trawls in the North Sea flatfish fishery. In order to fulfil the overall aim, predictive models of the effect of electric pulses on organisms and on different ecosystem components will be developed and applied. The results will be integrated to assess the consequences of a transition in the flatfish fishery from using tickler chain beam trawls to pulse trawls on the bycatch of undersized fish (discards) and the adverse impact on the North Sea ecosystem.

These aims lead to the following research questions:

1. Marine organisms: what is the response of selected marine organisms representing different groups of fish and invertebrate species (such as roundfish, flatfish, rays and sharks, bivalves, crustaceans, polychaetes) to the exposure by a range of pulse parameters representative for the commercial pulse trawls?

2. Benthic ecosystem: what is the effect of pulse trawling on the functioning and biogeochemistry of benthic ecosystems (short-term and long-term effects)?
3. North Sea: what is the effect of pulse trawling on the fish stocks and the benthic ecosystem at the scale of the North Sea? Does a transition in the flatfish fishery from conventional beam trawling to pulse trawling contribute to a reduction in bycatch and adverse impact on the benthic ecosystem?
4. Synthesis: what is the effect of the transition of the tickler chain beam trawl fleet to a pulse trawl fleet on the bycatch of undersized fish and on the adverse effects on the benthic ecosystem?

11.11 Spain

AZTI-Tecnalia

Basque Country, SPAIN

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The projects described below have been developed by AZTI-Tecnalia during last years, some of them have been finished and the others are ongoing projects. The projects have been developed in the new scenario of the European Fisheries Policy especially in the areas affected by the landing obligation.

Fish survival from slipping in purse-seine fisheries: the case study of European southern waters

Slipping (releasing fish before the net is fully hauled onboard if the catch is unwanted by the skipper) has been prohibited by the European fisheries regulation (Regulation EU No 227/2013) for herring (*Clupea harengus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). In the new regulatory framework (Regulation EU No 1380/2013; Article 15), an exemption to the landing obligation can be provided for species for which scientific evidence demonstrates high survival rates, taking into account the characteristics of the gear, of the fishing practices and of the ecosystem.

This study presents the results of experimental tests on survivability of several species subject to slipping in southern European purse-seine fisheries, i.e. mackerel, horse mackerel, anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), and chub mackerel (*Scomber japonicus*). Tests were carried out on board a commercial fishing vessel, which is representative of the purse-seine fleet of European southern waters; and they were conducted during real commercial fishing activity. High survival rates were found in the tests, particularly for crowding times of less than 10 minutes. This also suggests that the approach followed to simulate slipping, i.e. using fish tanks filled up with seawater on board to keep the catch in captivity, is suitable for discard survival studies as an alternative to other methods. This project finalized in 2015 but in 2016 a new project with similar objectives is going to start in forthcoming dates.

DESMAN (Discards Handling)

The new European regulations related to the landing obligation for all species with TAC have been applied in certain fisheries in 2015. The new scenario may involve a radical change in the fishing operational processes and handling on-board the fishing vessels.

Focusing on the handling of unwanted catch, it will mean a substantial increase in fish to be separate, classify, conserve, store, transport on-board and land, especially in some fishing methods such as trawling, where the discard levels still quite high.

This is an ongoing project that aims to: i) quantify the volume of the different unwanted species that could be associated to the fishing operations in the Basque fishing fleet, taking into account different fishing methods (inshore, offshore and artisanal fishing fleets); ii) assess the added effort and operational possibilities for different fishing boats to address the increased workload by handling due to the landing obligation; iii) Study the existing technical possibilities and new work processes to solve the problem of extra fish to be handled and iv) evaluate the potential increase in risks and their implications on the job security of the crews that will manipulate extra fish linked to compliance with the landing obligation. Project finalized in 2015.

Discard survival estimation and improvement in small pelagic purse-seine fisheries

The overall aim of this study was to analyse the survival of discarded species in the purse-seine fleet of the Basque Country in order to provide arguments to discuss technically and scientifically exemption of the landing obligation.

This is an ongoing project where we are trying to: i) Get discard survival rates according to the operational fleet. ii) Study the performance of the machinery or equipment on board that affect survival. iii) Identify and analyse the factors that determine the survival of discards. iv) Development of a good practices manual on catch handling to optimize the survival of discards.

The reasons for the discard in this fishery are the exhaustion of the quota and the absence of commercial value for some species. The main target species of the fishery are anchovy (*Engraulis encrasicolus*), sardine (*Sardina pilchardus*), mackerel (*Scomber scombrus*) and horse mackerel (*Trachurus trachurus*). These very same species can be discarded in relation with the discard reason mentioned above. The first part of this project finished in 2015 with promising preliminary results and it is planned to follow working this topic half 2016 and 2017.

Selectivity improvement in the pair trawl fishery targeting hake (Merluccius merluccius) in the Bay of Biscay ICES VIIIabd

The new regulation in relation with discards in the EU waters, named as Landing Obligation or Discard ban, has been implemented to the trawl fishery targeting hake in 2016. According to this regulation all the hake must be landed and registered against quota. The undersized hake must be landed separately from commercial catch and the use of these undersized catches shall be restricted to purposes other than direct human consumption. This is an important drawback for the fishery because it involves that a part of the quota cannot be achieved a return into.

In this context this project started with the aim of improve selectivity for hake reducing the catch of the juveniles. Two selectivity cruises were carried out during 2015 and another four cruises during 2016. During some of these cruises, hake behaviour has been assessed with underwater video and different configurations of a Square Mesh Panel have been tested. This project started in 2015 and it is expected to follow working on it until 2017.

Energy performance of fishing vessels and potential savings

Commercial fishing is heavily fuel dependant. The increase in the fuel price, together with the stock decline, occupational risks of fishing, the possibilities of finding a different future for new generations, are some of the reasons that have made fishing arrive at its 'survival limits', in many parts of Europe.

This contribution aims at providing ship owners and researcher with the experience of undertaking energy audits, to reduce the fuel bill of fishing vessels. In order to do so, 3 fishing vessels were assessed comprehensively, for 2010e2012, to determine their energy consumption flow. The results indicate that energy consumption depends upon: (a) the structure and size of the vessel; (b) the engine conditions and use patterns; (c) the fishing gears used; (d) the fishing and trip patterns; (e) the distance to the fishing ground; (f) target species and their migration routes; and (g) the traditions onboard. Likewise, no generalization can be made regarding the way energy is consumed by onboard equipment/machinery when different fishing gears are compared. Energy audits will need to be site-specific and to include sufficient data to obtain representative results; these are likely to be more than in land-based industries, due to the peculiarities of this sector.

On the other hand, this field has a huge potential to improve and still some ongoing projects at AZTI's energy efficiency pilot plant, related to: i) Development of a test bench for the recovery of residual heat from marine diesel engines for energy generation. ii) Tests, under controlled conditions, with fuel consumption and exhaust gases emissions reduction systems on specific test benches.

11.12 France

The technological works led in France in 2015 are distributed in 3 main topics:

- Improvement of selectivity / species survival;
- Lower impact on the seabed and energy savings;
- Alternative fishing gears.

Improvement of selectivity / species survival

"REDRESSE" project: selectivity in the Bay of Biscay

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The objectives of this project are to test strategies and devices allowing to reduce discards of the fishing fleets in the Bay of Biscay. This project concerns the following "*métiers*":

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

The project holder is the AGLIA (Association du Grand Littoral Atlantique). Other partners are Ifremer, CNPMEM (French National Fishers Committee) and the South-western Waters RAC (Regional Advisory Council). The financial partners are

« France Filière Pêche » association and the 4 Regions Councils of the Atlantic façade, Brittany, Pays de la Loire, Poitou-Charentes and Aquitaine.

The REDRESSE program allowed to carry out in 2014 and 2015 a large number of hauls by tested selective device. Most of the trials were realized using the twin trawl method allowing a strong comparison between the captures of the test and standard trawls. Among all the devices tested, a preliminary analysis was realized on T90 70 mm codend plus extension and a 90 mm square mesh panel in the top of the extension piece ("baitings").This last device was proposed by a captain involved in the project. It is a large extension (4 m x 2.2 m) of the mandatory square mesh panel used in the Bay of Biscay.

For the T90 data collected in the twin trawling "fish" fishery, the results show a significant reduction of the total discards (in average weight by haul, all species combined). The non-commercial species, dogfish, small hake and pout seem to escape by this device. However a commercial loss is observed, in particular on red mullet and squid.

The data analysis of captures obtained with the device "90 mm square mesh baitings" in the Nephrops fishery indicates a significant reduction of the discards, in particular small hake, horse mackerel, blue whiting and pout, without showing significant commercial loss. The detailed data analysis of the REDRESSE project is going on (modelling) for each of the devices tested.

New trials are also being held in 2016 on devices proposed by the fishers or with a new Nephrops hinged grid. Trials of square mesh panels are also in progress in the Danish seines in Sables d'Olonne. A numerical simulator of the behaviour of the seine was also realized in 2015.

"CELSELEC Project": Improvement of selectivity in the Celtic Sea

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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…

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

The trials begun in 2014 on T90, square mesh cylinder and monkfish grid continued in 2015 and the first analyses are available.

The CELSELECT program tests these devices on 6 referents boats. Every boat experiments a single selective device during a whole year. The data are collected by observers dedicated to the program; one trip (10 days) is observed by boat and by quarter on average. The last trips will be observed in spring, 2016 and an extension of the project is in progress to improve certain devices such as a new hinged monkfsh grid.

An additional experimental trip was realized in November 2015 to determine the selectivity curve of a trawl equipped with a 100 mm T90 extension and codend. This information will complete the catch comparison analyses and allow a rigorous quantification of size selectivity. This information will be also essential to assess the impact of the implementation of these devices through techniques of modelling of the populations and the mixed fisheries.

In the context of the new CFP (Common Fishery Policy) reform and the associated landing obligation, data analysis focuses on the species under quotas in Celtic sea. The most problematic species were identified based on the most recent syntheses of the French Observer at sea program OBSME (métier: bottom trawlers > 18 m fishing in the Celtic sea).

The intermediate results of the projects REDRESSE and CELSELEC were presented on October 22nd, 2015 on the occasion of the trade show ITECHMER in Lorient, in partnership with the project leaders, producers' Organization "The Fishers of Brittany" for the Celtic sea (CELSELEC) and the AGLIA for the Bay of Biscay (REDRESSE). A recording of the corresponding conference is available at (video/presentation in French): https://www.youtube.com/watch?v=WE67pNMJuPo

Video processing

In order to understand fish behavior facing selective devices in trawls, we placed a camera above the devices and recorded fish escapement. Then, we developed an image post-processing program to automatically detect fish. The program was tested on videos taken on bottom-trawls and Danish seine. Thousands of fish escaping the trawls through the selective devices were counted providing important dataset for understanding escapement behavior and dynamics. The software gave for each fish escaping the trawl an ID number and the time at which it escaped from the trawl. Initial results from automated video analysis clearly showed that the escapes were not random, but presented a structured escape behavior.

"ENSURE" project: Evaluation of discards survival

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This project was launched in June 2014 and will run until end 2016. It is carried out by Ifremer. The other partners are the " Haute Normandie" Fishers Committee, "Nord Pas de Calais" Fishers Committee and "Pays de la Loire" Fishers Committee. The project is financed by the association France Filière Pêche and by the Fisheries and Aquaculture French Authority.

The landing obligation is one of the main issues dealt by the new Common Fisheries Policy. Article 15 indicates that all species under TAC have to be landed; however the species for which high survival rate can be demonstrated scientifically may be exempted. In such context, the ENSURE project aims at 1) identifying the species that present a potential of survival after discard, 2) determining the optimal condition of survival and 3) describing the state of discarded individuals. These objectives will be reached from observations on board of commercial vessels: the vitality of discarded individuals will be assessed as well as their reflex impairments. The experimentations carried out will allow determining the maximum duration of emersion that can be obtained without compromising the survival. Once the lethal levels will be defined, the proportion of individuals discarded according to their vitality and reflex status will be estimated. In the meantime, individuals discarded alive will be tagged. Based on the significant explanatory variables and observations made on-board, technical and operational improvements will be proposed to ensure the best survival rates. The expected results should feed the discard plans relative to the three métiers addressed by the ENSURE project: bottom trawl targeting mixed fish species in the bay of Biscay and English Chanel, twin trawl targeting *Nephrops* in the bay of Biscay and trammelnets targeting sole in the English Channel.

SURTINE project to assess the survival rate of Nephrops discarded from trawlers in the Bay of Biscay

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The landing obligation is of the major point of the new common fisheries Policy. Article 15 indicates that species under TAC and quotas will have to be landed; however, species for which a high survival rate will be demonstrated scientifically could be exempted.

Nephrops survival after trawling in the Bay of Biscay was studied in 2010 (Mehault et al., in prep) following the methodology used by Guéguen and Charuau in 1975. The survival of undersized Nephrops[1] after commercial trawling, catch handling and 3 days of captivity on the fishing ground was estimated at 51% [42–60] in 2010. The Scientific, Technical and Economic Committee for Fisheries (STECF) considered that the 3 days of captivity period was not long enough to define a reliable mortality rate since its stabilization could not be demonstrated. However, based on these 2010 results, the European Commission agreed for a temporary exemption to the landing obligation of the undersized Nephrops for one year from the 1st of January 2016. A new exemption demand could be submitted in summer 2016 prevented that new scientific and technical evidences relative to Nephrops survival will be provided.

This new study, carried out under the SURTINE project, aims at assessing the discarded Nephrops survival rate in the Bay of Biscay by implementing the methodology recommended by the Workshop on Methods for Estimating Discards Survival (ICES, 2014). For that, vitality methods will be combined to captivity observations onshore. This experiment will consider both the current catch handling practices onboard of commercial vessels (scenario 1), as well as the project of equipping vessels with an evacuation system letting discards going back to the sea directly all through the catch sorting process (scenario 2).

"PREDADOR" project: Limiting predation of shells by gilthead sea breams

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This project, carried out by the Shellfish Farming Regional Committee of the south Brittany (CRC Bretagne Sud), studies the implementation of physical and acoustic barriers to rule out the predators (in particular the gilthead sea bream) of zones of shellfish farming (mainly mussels and oysters). It is funded by the Regional council

[1] Undersized Nephrops in the bay of Biscay: < 28mm cephalothoracic length or < 9cm total length

of Brittany, the Department of Morbihan, and by the contribution of the industrial and scientific partners.

The physical barriers defined during the last steering committee were installed in Bay of Quiberon at the beginning of May 2015. It was mainly squares 10 m aside of anchored nets, 2 m high, in 100 mm square meshes. No predation was observed on this site after 5 months of immersion, either in the reference zone or in the experimental squares. On the other hand, this experiment allowed to observe the very good behaviour of 100mm square mesh barriers designed according to our plans, with chain in the lower part and numerous floats on the headrope. No cleaning was necessary during 5 months despite the very important fouling, contrary to the regular cleanings every three weeks of 4m high nets barriers used by the professionals, fitted with much less floats.

Physical protections were also installed in the Gulf of Morbihan. It was also squares of 10 m on 10 m, in 100 mm square meshes, but only one meter high, set on the foreshore, between oyster farms. Oysters were placed as bait inside the square, as well as in a reference zone close by.

A strong predation of 80% was observed on the reference zone while no predation was noticed inside the physical barrier. Photos of sea breams consuming oysters of large size (13 cms in length) were able to be taken on the non protected reference zone.

Even if such a barrier seems effective and appears to confirm that sea breams do not pass over such an obstacle, it would be difficult to set up in a zone swept by very strong currents, accompanied with seaweeds, in the entrance of the Gulf of Morbihan.

These various observations strengthen the interest of barriers of 2 m high for the oyster farming, spread on the seabed in Bay of Quiberon.

The Ifremer's fishing technology team also continued its work of support to the acousticians to observe the reactions of various species of fish in the presence of acoustic deterrent in the river of Faou. The video footages obtained show in particular the indifference of sea bass and black sea breams of large size to the acoustic signals displayed; these observations are very important for reassuring the fishers, either professional or sailors, about the potential negative effects of acoustic deterrents.

Lower impact on the seabed and energy savings

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"Jumper": Optimization to lower seabed impact of trawl doors

"Jumper" project was a 24 months national project with private funds (FFP France Filière Pêche). It was a continuation of previously developed low impact trawl doors (part of DEGREE EU project and OPTIPECHE national project). The objective was 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 behavior, tank trials and field trials aboard 16m and 25m trawlers were undertaken along the project. Initial objectives have been reached: improved Jumper doors provide good trawl spreading and have very low impact. The shape of the lower part of the door produces a small hydrodynamic wake, as well as small impacted surface and forces applied on the seabed. Consequently, resuspension of sediment is very low (an order of magnitude lower than standard doors). The project ended in March 2015. Three additional trials onboard professional vessels intermediate positive feedback. By the end of 2015, this door model has presented in the French “Itechmer” fishing show.

Alternative fishing gears

“FREGATE” project: Experimentation of fish pots in the North Sea and Channel

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In parallel with its work on "engine technology", this project 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 onboard the private trawler “Frégate”. Trials focused on the ergonomics of pots handling onboard of a commercial trawler. So far catches were mainly composed of pouts, whiting and crustaceans. Unfortunately, no results are available on cod since the trials had to be carried out of its fishing season (technical constraints).

“Large fish pots” experiments

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This project is funded by the Fisheries and Aquaculture French Authority, in a general program aiming to improve selectivity.

Two new types of fish pots of large dimensions were built, one on a model of fish pot tested in Norway in the vicinity of salmon cages[2], the other one on a collapsible concept developed by Ifremer. In both cases, the idea is to test the potential of capture of fish pots of large dimensions, on species other than conger, pout or cod, for example sea bass, sea bream or pollack. The experiments are going on in 2016 by comparing these two fish pots with more standard models, in the Brest harbour.

“PASAMER” project, experimental longline for black scaboard and hake fishing

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“Pasamer” if a national co-funded project involving Scapêche fishing company. It aims at settling profitable longline fishing for a 33m trawler converted to longliner to reduce by catch, fuel consumption and physical impacts on the seabed. A first period was dedicated to the training of the crew who was new to this métier. This period was based on the use of benthic longlines. The fishing company objective is also to target hake and black scaboard fish in deep waters. Thus off-bottom longlines have been designed, using a simulation tool developed for this project. A sea trial was undertaken at the end of 2015. Measurements using depth sensors were achieved on off-bottom and benthic longlines in order to validate simulation results. Sinking velocity, which is important for the bait efficiency, and longline shapes were found in good

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[2] Kasparas Bagdonasa, Odd-Børre Humborstad, Svein Løkkeborg, 2012. Capture of wild saithe (Pollachius virens) and cod (Gadus morhua) in the vicinity of salmon farms: Three pot types compared, Fisheries Research.

accordance with the model prediction. We noticed a strong effect of undercurrents on the line behaviour, and unfortunately low catch of pelagic fish, presumably due to the choice of working areas. The project will end mid-2016.

11.13 Denmark

Danish Technical University (DTU AQUA)

Fast-Track - Sustainable, cost-effective and flexible gear solutions under a landing obligation

The project aims to establish a platform comprised of stakeholders (fishers, netmakers, producer organizations, managers and scientists) with the intention to promote the development of ideas and solutions originating in the industry. Furthermore, the project aims to facilitate and fast track the testing of new designs proposed by stakeholders and their implementation in legislation.

With the reform of the EU Common Fisheries Policy and the introduction of a Landing Obligation the ability of fishers to adjust the selectivity of their gears to suit the quotas which are available to them will be an important factor in determining the revenue and rentability in the fishery. As the combination of gear, fishing practice and quota shares will differ between vessels, changes to the selectivity of the gears will need to be implemented at the vessel level and based on the quotas which are available to the vessel at a given time. For this to be realized, simple and cost-effective solutions which can be quickly coupled with existing gears will be in demand. These solutions will need to be implemented quickly in order for them to solve the issues at hand without losing substantial income. Furthermore, these solutions will need to be scientifically tested to document their effect before being considered for implementation into the legislation. A description of the project as well as the work being carried out in the project can be found on the project homepage: www.fast-track.dk

Review on programs established to encourage industry-led approaches to selective gear development

Contact: Jordan Feekings (jpfe@aqua.dtu.dk)

DTU Aqua is putting together a review on programs established to encourage industry-led approaches to selective gear development (e.g. Cefas – The 'Clean Fishing' competition, DTU Aqua's MINIDISC project providing fishers with free gear choice, WWF smart gear competition). The idea is that such collaborative projects (a bottom up approach) have a better success rate of implementing selective gears as opposed to a top down approach where selective gears are enforced into legislation and the selective performance of these gears negated. We also intend on looking into where the legislative structures in certain countries inhibit such types of programs from being undertaken.

The fate of discards in the benthic environment

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DTU Aqua carried out a trial (May 2015) to determine what key species are scavenging on discards. Under the new EU common fisheries policy there is a ban on discards of commercial species. This will reduce the biomass of discarded material which reaches the seabed. This trial aimed to understand what species may potentially see a shortfall in their food due to the new CFP.

Danish seine – Ecosystem effects of fishing

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Since the amount of scientific studies on Danish seining is rather low, the current study "Danish seine – Ecosystem effects of fishing" tries to cover various topics to increase the knowledge of impacts, Danish seines have on the environment and to give advices to potentially improve selectivity characteristics and efficiency of the gear. We conducted a catch profile comparison to bottom trawls based on a perennial observer dataset and carried out two sets of experimental trials on commercial vessels. The first set in 2014 looked at codend selectivity as well as direct interactions, the gear has on the benthic and demersal fauna. The second set of trials in 2015 allowed us to create detailed descriptions of the fishing process in terms of geometry and forces acting between net and ropes and furthermore, to evaluate the behaviour of fish in relation to the gear and to evaluate impacts of the gear on the seabed.

Gear technical contributions to an ecosystem approach in the Danish set-nets fisheries

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Although the fleet has reduced since the mid-1990s, Danish gill- and trammelnets are still of importance and are likely to gain increasing interest as environmentally friendly practices. However, such a development may only happen if the ecosystem approach is guaranteed. There is limited knowledge of ecosystem impacts, such as for example physical damage to habitats or discards, and their minimization may require development of alternative practices. With regard to the upcoming challenges of an Ecosystem Approach to Fisheries, the project aims at (1) studying the sweeping behaviour of nets and their effect on the seabed; (2) quantifying invertebrates and fish discards and understanding how the capture process can influence discard behaviour; (3) developing technical innovation that could improve catch quality and therefore maximize the production. Trials are conducted on gill- and trammelnets within the Danish coastal waters. This is a PhD run as part of the Skånfisk project financed by the Ministry of Food, Agriculture and Fisheries of Denmark.

Identifying simple and cost-effective gear solutions which can lead to an effective implementation of the new EU Common Fisheries Policy (CFP)

Contact: Valentina Melli, PhD student, (vmel@aqua.dtu.dk)

This PhD project is focused on the Danish Nephrops-directed mixed species trawl fishery, a poorly selective technique that will be strongly affected by the new CFP. The main goal is to develop simple and flexible gear solutions that will improve the sizes and/or species selectivity in the gears and will be constructed to facilitate fast mounting and de-mounting of systems in the trawl to allow a very flexible use on a haul-by-haul level. To do so, we'll work on the gear design at several levels: using both mechanical and behavioural stimulations we'll make use of species-specific differences to isolate Nephrops from all fish species. Consequently, we expect to substantially reduce the discard fraction by either preventing fish entrance in the net or leading them into a different compartment, where they may be sorted more accordingly to their sizes and morphologies. Furthermore, a design that aimed at increasing Nephrops catchability will be tested, enhancing the goal of implementing fishers ability to reach their Nephrops quota.

Industry led gear selectivity improvements, its strengths and weaknesses in the new Common Fisheries Policy (CFP).

Contact: Tiago Malta (timat@aqua.dtu.dk)

With the goal of increasing fishers' sense of ownership of the gears available to the industry the project will scientifically test gear selectivity solutions developed by the industry with the aim of solving the issues faced under the new CFP landing obligation system. The project will also attempt to understand whether gear selectivity data collected by the industry can be used as a fast and cost-effective way to obtain efficient and accurate data on species and size selectivity in the gears. With the purpose of ensure the quality of the industry-collected data with the minimum impact in the fishers workload the optimization of the data collection protocol will be conducted. The protocol optimization will be carried out using stochastically simulated data and it will primarily aim to determine the minimum number of fish needing to be sampled during commercial fishing to maintain the necessary data quality. This will be evaluated in terms of provided catch comparison and ratio information and associated uncertainties. Furthermore, by discussing the strengths and weaknesses of industry collected gear selectivity data and how its collection can be streamlined under the new CFP we hope to increase our understanding of a wider range of fishing gears selectivity issues. We expect that new and innovative solutions will be presented by the industry and that the project will be able to provide guidelines for a faster implementation of those solutions in the legislation.

Understanding and predicting size selectivity and escape mortality in commercial zooplankton fisheries: case study on Antarctic krill. SILF

Contact: Ludvig A. Krag (lak@aqua.dtu.dk)

The volume of the present fisheries on Antarctic krill is modest and considered to have a significant potential to increase. This resource is considered to be one of the least exploited fisheries worldwide. There are, however, expressed concern regarding future sustainable harvesting and what affect the fishery can inflict other animals that depend on krill. These are typically set in the context of ongoing changes in the environment, affecting production, distribution and life cycle of krill. Today many different types of fishing gear to catch krill are utilized. A pilot study (NEAT) used both mathematical modelling techniques and practical experiments on larger selection of krill in trawl, demonstrates that krill can escape even from some of the smallest commercial meshes used in the fishery. Because of major gaps in knowledge of this marine ecosystem and potential adverse effects that may be caused by an increased fishery, both the Commission and the scientific committee of the CCAMLR (Convention on the Conservation of Antarctic Marine Living Resources) strongly requested the need for more knowledge of indirect effects of various fishing gear on krill mortality. Indirect mortality in this context includes krill that die after being in contact with the fishing gear due to injuries. In this study, we assess mortality as a result of that they've escaped trawl masks, establish selectivity properties of krill with different sizes for all types of trawl design being used in today's fishing, including trawl panels and the codend. We will produce a set of design guides that allow the evaluation and optimization of trawl design being used in the commercial krill fishery to reduce possible negative effects on the ecosystem and to streamline fishing effort. There is an urgent need to address these issues, also in consideration of the development of other new and exploratory fisheries. The project is made in collaboration with IMR, Bergen and SINTEF, Hirtshals and is financed by the Norwegian Research Council.

Test and development of an Excluder system in the Danish industrial fishery for Norway pout.

Contact: Ludvig A. Krag (lak@aqua.dtu.dk)

The project aims at testing and further developing the Excluder system for Danish trawl fisheries. The Excluder system is used on a voluntary basis in Alaska today in the flatfish fisheries and the systems design principals have a potential to improve both the sizes and species selectivity in several fisheries in EU waters. The Excluder system however needs to be modifies and tailored for these fisheries. The system will initially be tested in the industrial fishery for Norway pout where there is bycatch of gadoid species and herring. With the landing obligation system, which is introduced into the EU waters by the new Common Fisheries Policy there is a great need for selective systems that can improve the fishers ability to improve both species and sizes selectivity. The project is made in collaboration with the Pelagic Fishers's Association, TORMO trawl and SINTEF Hirtshals.

Optimizing the economic value of the fish catch in the Danish mixed fisheries (VærdiFisk)

Contact: Junita D. Karlsen (jka@aqua.dtu.dk)

This project was conducted in close collaboration with netmakers, fishers, exporters, fishers's collecting central, the fish auction and the Danish Fishers's association. A vertically divided codend showed prospects of increasing the income in the Danish mixed fishery by improving the quality of fish as well as increasing the size selection while retaining valuable catch compared to a standard codend. Successful separation of fish and organisms with hard and spiny outer surfaces led to significant improvements of several quality parameters of whole fish, fillets and *Nephrops* in several steps of the value chain. Quality improvements were observed by exporters, who dectate fish prices, and has influences on scientists. There was an indication of reduced stress in fish caught in the vertically divided codend and so there may be a potential of prolonging the shelf life of fish caught in trawls as well as improving animal welfare. The different netting in the upper and lower parts of the vertically divided codend was customized to increase the selection of small fish and *Nephrops*, respectively, while retaining the most valuable catch. The experimental codend had 10% higher catch rate of *Nephrops* compared to the standard codend. Increasing the efficiency of the fishery gives less fuel consumption per kilogramme *Nephrops* caught, and may, if evaluated over longer time periods, imply less impact on the seabed.

SEAL-SAFE

Contact: Lotte Kindt-Larsen, lol@aqua.dtu.dk

In order to both conserve a sustainable fishery and avoid the risk of porpoise bycatch a project "SEAL-SAFE" was initiated to develop cod pots, as these can be protected against raiding seals and do not have porpoise bycatch. The project is collected in the Danish part of the Baltic Sea where different cod pots are being tested in commercial fisheries. The trials are testing how catch rates are affected by (1) floating or bottom deployment, (2) size/volume, (3) rearrangement of catch cambers to vertically instead of horizontally or left out, (4) how different entrance design influenced catch escape and (5) and the economic feasibility of using cod-pods.

11.14 Italy

CNR Institute of Marine Sciences (ISMAR)

Fishing Technology Unit, Ancona, Italy

Antonello Sala, Sara Bonanomi, Fabrizio Moro, Emilio Notti, Jacopo Pulcinella

EU Project BENTHIS (Grant Agreement No 312088)

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.

The activities carried out for the Mediterranean case study focused on the evaluation of the performances of experimental otter boards and on the design and test of some innovative modification of the bottom trawl. Two Italian door manufacturers, involved in the project as SMEs, developed two innovative otter boards aiming at reducing the physical seabed impact, using as a reference the Thyboron VF15 pelagic otter board. A complete cycle of tests has been deployed; including facilities tests in wind tunnel and flume tank and sea trial onboard the RV and a commercial bottom trawler.

Some relevant modifications on the design of a typical bottom trawlnet was carried out on June 2015. One of the nets of a twin trawl fishing gear has been modified in central part, in order to compare net openings and catch for each haul carried out. More in details, according to a preliminary project from TECNOPESCA (Spain), and further developed by SME14 a separator was implemented in the mouth of the net, while later panels along the separator were made with same net type of the codend. Catch comparison and selectivity analysis will allow for a complete evaluation of the efficiency of such modifications. Furthermore the implementation will be evaluated from the energy efficiency perspective. More info at: www.benthis.eu.

EU Project EFFICIENTSHIP (LIFE13 ENV/FR/000851)

The EfficientShip project will demonstrate the efficiency of an innovative ORC technology for reducing the GHG emissions of thermal engines. 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 war-

ming and to offer them some simulation on the adaptation of the EfficientShip innovation on their vessels.

An Irish vivier crabber has been selected for the implementation of the ORC system. The electrical energy produced for water pumps will be supplied by the ORC system in order to reduce the load of auxiliary engines. The reduction on engine load will determine a reduction in fuel consumption and in GHG emissions. The ORC system will recover the heat by the exhaust gas pipe of the main engine and the remaining heat will be discharged by the heat exchangers of the vessel.

The sea trials have been scheduled for the period May-December 2016. The evaluation of the effects of the implementation will be assessed through a fuel consumption monitoring system which will be independent by operators and data collected will be forwarded to an ftp server. The monitoring system activity is started on 15th April 2016, and for three weeks the fuel consumption of the gensets will be monitored in normal conditions. More info at: www.efficientship.eu.

Demersal Fisheries Discard In Italian Waters: Preliminary Assessments for the Implementation of Community Provisions Concerning the Landing Obligation (EU Regulation 1380/2013, Art. 15)

In the light of the future entry into force of the provisions on the landing obligation for demersal species, it is necessary to develop a concise and comprehensive characterization on the problem of discards, in order to have relevant information useful for the implementation of the provisions of the new regulation. This project shows a number of innovative features, which are not limited to simple critical review of existing data. In particular we will be evaluated:

- the estimated discard rate due to specimens below the minimum landing size;
- the selectivity of fishing gear for the capture of demersal species and simulations of possible scenarios induced by the increase of the mesh size of bottom trawls
- logistical issues related to the management of discard on board and at landing sites
- the identification of potential new lines of market for the commercialization of species obliged to land.
- the potential impact, in terms of bioeconomic development, of the application of EU reg. 1380/2013, art. 14/15, through simulation of specific scenarios.

BYCATCH VI

The project is an extension of previous monitoring programmes (BYCATCH I, II, III, IV and V) of accidental catches of cetaceans by Italian pelagic trawling. The programme was funded by the Italian Ministry of Agriculture, Food and Forestry, in compliance with Regulation (EC) No. 812/2004. Under this regulation, '*Member states shall design and implement monitoring schemes for accidental catches of cetaceans […]*'. The programme also includes monitoring of other species of conservation concern such as sea turtles and elasmobranchs which are considered vulnerable species to commercial fishing. Several observations on board pelagic trawlers have been previously carried out to record cetacean's interactions with trawling, bycatch events and all fishing operations including towing, hauling and discard. In order to reduce bycatch events, CNR-ISMAR of Ancona led sea trials to test mitigation measures such as TED (*Turtle*

Excluder Device) and acoustic pingers. From preliminary analysis, grids exhibited a good escape cover performance while acoustic deterrents showed a poor efficiency in chasing away dolphins during fishing operations. Further investigations are required in order to optimize TED performance and to understand cetacean's behaviour against pinger.

CAPGEMINI

The European Commission, Directorate General MARE, launched a study on the economic impact of ancillary and complementary services related to marine fishing and aquaculture in EU-28.

In this contest, CNR-ISMAR of Ancona will perform a series of interviews and desk research in order to:

- establish the number of jobs by activities ancillary to marine fishing, inland fishing and aquaculture at regional level;
- provide insight and an estimate of the income established by ancillary activities in the abovementioned sectors;
- provide insights in the complementary activities created, in terms of jobs and income generate in these complementary activities for recreational fisheries for the mentioned sectors.

The overarching goal of this survey is to gather data on the ancillary and complementary services of the Italian fishing industry. This valuable information will provide a better overview of the employment and income generated in ancillary and complementary services related to marine fishing and aquaculture.

CARREFOUR

Carrefour Italy has committed to supply its customers with certified sustainable seafood products to promote responsible fishing policy. In this contest, CNR-ISMAR of Ancona is carrying out an extensive desk research to review knowledge of the current sustainability status of Carrefour Italy's seafood products. For each species, fishery scientists are examining the fishing distribution, stock status, and fishing gears based on the best available scientific information. The outcome of this assessment will be converted into a coloured labels designed to raise consumer awareness about the importance of buying seafood from sustainable sources.

Permanent fuel consumption survey onboard commercial fishing vessel

A fuel consumption monitoring system was set up for research purpose in order to evaluate the energy performance of fishing vessels under different operating conditions. The fuel monitoring system conceived at CNR-ISMAR Ancona (Italy) consists of two mass flow sensors, one multichannel recorder and one GPS data logger. Fuel consumption rate and vessel speed data were used to identify energy performance under different vessel-operating conditions. The system is an effective means to monitor engine and vessel performance, but can be also used to give a real-time indication of engine fuel economy on a commercial fishing vessel.

The monitoring activity started on 2008 with two pelagic pairtrawlers. On 2010 a first bottom trawler was included in the monitoring plan, followed by another with different size on 2013. In 2015 a Rapido trawler (FAO Code: TBB) was also included and finally in 2016 another bottom trawler was selected as it use to change periodically fishing gear from a single bottom-trawlnet to a twin trawlnet along the different fishing seasons.

12 Other Business

12.1 Selection of ICES Chair

The current ICES Chair informed the group during the intersessional period of the opportunity to nominate or identify potential candidates for the incoming ICES WGFTFB Chair to serve from January 2017 until December 2019. Only one candidate, Haraldur Einarsson of Iceland, was proposed to the group. At the request of the ICES WGFTFB Chair, the candidate was asked to make some remarks on his plan as the co-chair of WGFTFB. Haraldur Einarsson was thus nominated and approved by unanimous acclimation for the next chair of the WGFTFB. The WGFTFB requests that SCICOM approves Haraldur Einarsson (Iceland) as the next chair of WGFTFB at its September 2016 meeting.

12.2 Date and Venue for the 2017 WGFTFB Meeting

The **ICES/FAO Working Group on Fishing Technology and Fish Behaviour** will meet in Nelson, New Zealand on 3–7 April 2017 at the invitation of New Zealand's National Insitute of Water and Atomspheric Research (NIWA). The meeting will include a joint session (JFTAB) on Monday 3 April 2017 with the Working Group on Fisheries Acoustics and Fishing Technology (WGFAST).

12.3 Topic Groups for the 2017 WGFTFB Meeting

Ongoing Topic Group: Change Management in Fisheries (Change)

A WGFTFB topic group convened by Steve Eayrs (USA) and Michael Pol (USA) will continue at the 2017 meeting 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.

Terms of reference:

1. Evaluate the applicability of change management concepts and models in a fisheries context
2. Review and evaluate fisheries case studies and initiatives to bring about change, including Knowledge networks, Environmental Management Systems, Fisheries Improvement Projects, and others
3. Explore models of human behavior that may contribute to resistance to change
4. 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.

Ongoing Topic Group: Contact Probability of Selective Devices (Contact)

A WGFTFB topic group of experts convened by Daniel Stepputtis (Germany) and Bent Herrmann (Denmark) will continue 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.

Terms of reference:

1) Summarize current and past work in relation to contact probability
2) Discuss and describe methods (experimental and statistical) to investigate and quantify contact probability
3) 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.

New Topic Group: Evaluation of trawl groundgear for efficiency, bycatch and impact on the seabed (Groundgear)

a) A WGFTFB topic group convened by Roger B. Larsen (Norway), Antonello Sala (Italy) and Pingguo He (USA) will be formed and will meet in April 3-7, 2017 in Nelson, New Zealand to discuss and summarize status and progress and knowledge of designs of groundgear and other components dragged along the seabed during bottom trawling. The topic group will evaluate current and past work regarding to their efficiency for target and bycatch species, effect on the seabed, and energy use. This topic will include past, current and future studies from a wide range of scientific fields, such as hydrodynamics, drag and gear design, strategies and technology enhancing reduced fuel consumption and reduction in gas emissions, selectivity and behaviour on fish, shrimp and crab.

b) Terms of reference:

1. Describing and summarizing current and past work in relation to seabed contact/impact of various types of bottom-trawl groundgear.
2. Discussing and describing possible methods to reduce unnecessary bottom contact and fuel use due to the groundgear.
3. Discussing and summarizing the effect of trawl groundgear on the efficiency and selectivity for target and bycatch species.
4. Making recommendations on future experimental and theoretical work to understand and improve the function of groundgear of bottom trawls.
5. Making recommendations on the "best practice" regarding the design and operation of bottom trawls with less effect on ecosystem and emission.

Justification:

With uncertainties around the use of groundgear in bottom trawling and its impact on bottom fauna, it is important to review the current status of the design and use of groundgears in various fisheries and to propose new investigations that will contribute to more environmentally-friendly fishing gears. Continuous contact between gear and seabed during bottom trawling is believed to be of importance for efficient harvesting in many groundfish fisheries, but in some bottom trawls, total weight of the trawl may be out of proportions for the purpose. High fuel consumption in trawl fisheries is often associated with heavy groundgear being dragged along the seabed. Recent research and practices in the North Pacific and Northwest Atlantic bottom-trawl fisheries indicate that ground-contacting components including groundgear can be modified with no or little impact on the catch of target species. In the Northeast Atlantic, bottom trawling is often performed in areas of important fisheries for king crab and the rapid growing snow crab fishery, with unknown impact on these crab stocks. As crab fisheries increase in intensity, more gears will be damaged and lost due to collisions between trawl and pot fisheries. Alternative and lighter groundgears have been tested, but it is unclear if they are efficient for retaining target species and not increasing the catch of unwanted bycatch compared to conventional configurations. Discussion and summary of current knowledge and possible future development of bottom trawl gear or its alternatives for harvesting traditional groundfish species.

New Topic Group: Assessment on energy use and fuel consumption in fisheries (Energy)

A WGFTFB topic group convened by Emilio Notti (Italy) and Steve Eayrs (USA) will be formed and will meet in April 3-7, 2017 in Nelson, New Zealand to discuss the state-of-the-art in energy audit data collection protocols and collect summary information on energy use in fisheries. A deeper analysis of energy consumption through standardization of the energy profile of fishing boats is a keynote action for a better understanding of different fishing activities, including comparison of audits between fleets. Collection of information of the most relevant technical specifications will allow for a characterization and a comparison of different fisheries among different areas, and prioritization of future research efforts. The efficiency of several fisheries will be compared using common performance metrics such as catch/fuel consumption ratio.

Terms of reference:

1. Identification of energy audit testing protocols and performance metrics e.g. country, fisheries, fleet sector, etc., including monitoring of GHG emissions;
2. Evaluation of the potential to harmonize audit protocols for information collection of energy use in different fisheries;
3. Design of a general dataset for data and information collected, open data;
4. Definition of performance metrics e.g. l/h; l/kg of catch, litre of fuel/nautical mile etc., and identify and discuss equipment and tools to evaluate performance;

Outcomes

The scope of this term of reference is a preliminary review of energy consumption related to fisheries based on general observation, by fleet, type of fishery, country, using a standard methodology so results from different areas could be more easily compared. It is expected to identify key/critical areas for future deeper analysis based on a standardized protocol of energy audit, and to evaluate the potential application of a standardized protocol across multiple fisheries or countries.

An information collection form will be circulated among FTFB partners. On the basis of information collected, the topic group will discuss and define metrics and methodologies to be applied, and recommendations and advice will be given to overcame similar constrains and challenges, including audit protocols and data collection.

The Topic Group will invite presentations from individuals with experience in energy audits and energy conservation. Additional discussion will compare and contrast audit protocols and evaluate related performance metrics, with a view of providing guidance for future audits.

12.4 Joint Session

The Joint Workshop of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour [WGFTFB] and the Working Group on Fisheries Acoustics Science and Technology [WGFAST] (JFTAB), chaired by Paul Winger (Canada) and Chris Wilson (USA), will meet on 3 April 2017 in Nelson, New Zealand in conjunction with WGFTFB and WGFAST annual meeting to:

a) Review the observer effect: how platforms and instruments affect the behaviour of aquatic fauna.
b) Review recent progress in image analysis and machine learning techniques for efficient data processing in aquatic research.

JFTAB will report by June 30, 2017 for the attention of WGFAST, WGFTFB, ACOM and SCICOM.

Supporting information:

Priority	WGFAST and WGFTFB have joint interests in the effects of observation methods on behaviour of fish and other marine organisms and the use of image analysis methods.
Scientific justification	Term of Reference a) All observation methods and platforms impact fish behaviour and consequently acoustic measurements and fishing gear catch performance. A group of acoustic and fishing technology experts is therefore well suited to discuss progress in the field from different perspectives. Term of Reference b) Optical imaging methods are increasinlgy used as auxiliary methods in various fields, including fisheries acoustic and gear technology studies. Both groups of experts can benefit from sharing their diversity in collecting and analysing optical data.
Resource requirements	The monitoring and 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	Members of WGFTFB and WGFAST and guests (120 participants expected).
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	There are linkages to both SCICOM and ACOM.
Linkages to other committees or groups	There are linkages to all groups collecting or using data from acoustics, optics or fishing gears.
Linkages to other organizations	The work of this group is of international interest to all countries conducting surveys.

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Annex 2. Agenda

	SUNDAY APRIL 24	
Hyatt Regency (Swimming pool area)		
16:00		Registration
18:00		Welcome dinner
	MONDAY APRIL 25 HYATT REGENCY	
8:00	Registration	
9:00	Opening/Welcome Dr Francisco Espinosa, Director of Research, Marista University of Merida Dr Petri Suuronen, FAO, United Nations Dr Pingguo He, University of Massachusetts Dartmouth Dr Juan Carlos Seijo, Marista University of Merida	
9:30	***Session 1: Challenges and advantages in static fishing gears*** *Facilitators: Daniel Aquilar (Mexico) and Pingguo He (USA)*	
	Keynote presentation **Juan Carlos Seijo**, Marista University of Merida (Mexico) Selecting from alternative bycatch reducing technologies under fish and fishers behavioral uncertainties: A decision theory approach	
10:00	**Heui-Chun An**, Jae-Hyun Bae, Pyung-kwan Kim, Seong-Hun Kim, Byoung-Sun Yoon, National Institute of Fisheries Science (Korea) Fishing efficiency and bycatch rate of whelk trap depending on the shape of trap and net materials in the Uljin waters, Korea	
10:20	**Peter Ljungberg**, Sara Königson, Sven-Gunnar Lunneryd, Maria Hedgärde Swedish Agricultural University (Sweden) Can we develop species selective fisheries using salmon pontoon traps?	
10:40	**Break**	
11:10	**Keiichi Uchida**, Kohei Hasegawa, Hiromichi Ogawa, Seiji Akiyama, Hideki Noro, Yoshinori Miyamoto, Tokyo University of Marine Science and Technology (Japan) Behavioral observation of young bluefin tuna *Thunnus orientalis* and yellowtail *Seriola quinqueradiata* in the set-net using an ultrasonic Biotelemetry	
11:30	**Lotte Kindt-Larsen**, Maria Hedgärde, Casper Willestofte Berg, Finn Larsen, Sara Königson, Technical University of Denmark (Denmark) Development of cod pots as fishing tool to solve the conflict with seal depredation and harbour porpoise bycatch	
11:50	Lotte Kindt-Larsen, **Sara Königson**, Maria Hedgärde, Peter Liungberg, Swedish Agricultural University (Sweden) Observations of fish behavior in and around passive fishing gear: an efficient tool in fishing gear development	
12:10	General discussion	
12:40	Lunch	
14:00	***Session 2: Encouraging technological change in capture fisheries*** *Facilitators: Steve Eayrs (USA) and Mike Pol (USA)*	
	Keynote presentation **Steve Eayrs**, Gulf of Maine Research Institute (USA) What role can organizational change management play in encouraging change in capture fisheries?	
14:30	**Oswaldo Huchim**, Juan Carlos Seijo, Marista University of Merida (Mexico) Health and socio-economic effects of hookah diving fishing technology in small-scale	

	fisheries: A qualitative risk assessment
14:50	Jordan Feekings, **Ludvig Krag**, Tiago Malta, Henrik S. Lund, Søren Eliasen, Clara Ulrich, Technical University of Denmark (Denmark) Industry-led fishing gear selectivity improvements: How can we increase flexibility and ownership over the gears used while ensuring an effective introduction of the new EU Common Fisheries Policy?
15:10	**Tomas Willems**, Annelies De Backer, Magda Vincx, Kris Hostens, ILVO – UGENT (Belgium) Improving tropical shrimp fisheries through eco-labeling: experiences from the Suriname seabob fishery
15:30	Discussion
15:40	Break
16:10	**Arne Kinds**, Kim Sys, Laura Schotte, Koen Mondelaers, Hans Polet, Institute for Agricultural and Fisheries Research (Belgium) VALDUVIS: An innovative approach to assess the sustainability of fishing activities
16:30	**Alvaro Hernandez**, Marista University of Merida (Mexico) Fishing gear related to octopus behavior in the *Octopus maya* fishery of Yucatan shelf
16:50	General discussion
17:00	End

	TUESDAY APRIL 26 HYATT REGENCY
8:00	Opening/Logistics/Announcement
8:10	***Session 3: Energy and greenhouse gas (GHG) reduction in capture fisheries*** *Facilitators: Antonello Sala (Italy) and Liuxiong Xu (China)*
	Keynote Presentation **Antonello Sala**, National Research Council (Italy) Emerging issues on energy use in fisheries and development of low impact and fuel efficient gears
8:40	**Steve Eayrs**, Petri Suuronen, Bundit Chokesanguan Gulf of Maine Research Institute (USA) Application and review of energy audit protocols in the commercial fishing industry
9:00	**Emillo Notti**, Antonello Sala, Fabrizio Moro, National Research Council (Italy) Efficientship: fuel saving in fisheries through heat recovery from main engine – a case study in Ireland
9:20	General discussion
9:30	***Session 4: Technology and practice for managing bycatch and reducing discards*** *Facilitators: Petri Suuronen (FAO), Julio Garcia (Argentina) and Mario Rueda (Colombia)* Keynote presentation **Roger Larsen**, The Arctic University of Norway (Norway) Effort to minimize unwanted bycatches in the Northeast Atlantic trawl fisheries: A brief review of 40 years' research and current status
10:00	**Ludvig Krag**, Bjorn Arne Krafft, Bent Herrmann, Arill Engaas DTU Aqua, Technical University of Denmark (Denmark) Employing a trawl independent multi-compartment towing rig to study selectivity of crustaceans in trawls
10:20	**Luis Arregi**, AZTI Foundation (Spain) Technology and practice for managing bycatch and reducing discards
10:40	**Break**

11:10	**Mario Rueda**, Alexander Girûn, Jorge Viaòa Marine and Coastal Research Institute – INVEMAR (Colombia) Reduction of the shrimp bycatch from tropical trawling on the Colombian Pacific
11:30	**Haraldur Einarsson**, Hjalti Karlsson, Einar Hreinsson MRI-Iceland (Iceland) Illuminated area in front of a topless trawl in order to reduce bycatch in shrimp fisheries.
11:50	**Daniel Stepputtis**, Juan Santos, Bent Herrmann Thünen Institute of Baltic Sea Fisheries (Germany) One step beyond: identification of 'improved selectivity' using selectivity experiments and population models for brown shrimp (*Crangon crangon*) beam trawl fishery in the North Sea.
12:10	**Junita Karlsen**, Ludvig Krag, Bent Herrmann, Henrik Lund DTU-AQUA, Technical University of Denmark (Denmark) Using fish behavior to separate fish from Nephrops in a horizontally divided codend in the mixed trawl fishery
12:30	General discussion
12:40	Lunch
14:00	**Aimee Leslie**, Damon Gannon, Leigh Henry, Rab Nawaz, Heidrun Frisch WWF International (Switzerland) A global analysis of cetacean bycatch and mitigation measures
14:20	**Daisuke Shiode**, Maika Shiozawa, keiichi Uchida, Seiji Akiyama, Yoshinori Miyamoto, Fuxiang Hu, Tadashi Tokai, Yoshio Hirai Tokyo University of Marine Science and Technology (Japan) Development of a turtle releasing system (TRS) for set-net fisheries
14:40	**Michael Pol**, Steve Eayrs Massachusetts Division of Marine Fisheries (USA) Avoidance of Atlantic cod with a topless trawl in the New England groundfish fishery
15:00	Juan Santos, **Bernd Mieske**, Daniel Stepputtis Thünen Institute of Baltic Sea Fisheries (Germany) Be FLEXible: a simple and cheap flatfish BRD concept for roundfish trawl fisheries
15:20	**Carwyn Hammond**, NOAA Fisheries AFSC (USA) Trials and tribulations of halibut bycatch reduction in Alaska's Bering Sea trawl fleet
15:40	Break
16:10	**Pieke Molenaar**, IMARES (The Netherlands) Flatfish survival assessment carried out in 2014-2015
16:30	**Liming Song**, Zhihui Zheng, Kai Xie, Hailong Zhao Shanghai Ocean University (China) Effects of environmental variables on bycatch rates of *Acanthocybium solandri* in waters near Cook Islands
16:50	Petri Suuronen, **Carlos Fuentevilla**, FAO Sustainable management of bycatch in Latin America and Caribbean trawl fisheries – transforming wasted resources into a sustainable future
17:10	**Chryssi Mytilineou**, Chris Smith, Caterina Stamouli, Persefoni Megalophonou Hellenic Centre for Marine Research (Greece)
17:30	End

WEDNESDAY APRIL 27
HYATT REGENCY

8:00	Opening/Logistics/Announcement
8:10	***Session 5: Innovative technologies for observing fish and fishing gear***

	Facilitators: Daniel Stepputtis (Germany) and Pingguo He (USA)
8:10	Keynote Presentation **Barry O'Neill**, Marine Scotland (UK) A review of technologies for observing fish and fishing gear underwater
8:40	**Julien Simon**, Benoît Vincent, Sonia Mehault, Dorothee Kopp, Pascal Larnaud, Marianne Robert, Fabien Morandeau, Jean Philippe Vacherot Ifremer (France) Automated images processing a tool for better understanding of fish escape behavior
9:00	**Liuxiong Xu**, Xuchang Ye, Guoqiang Xu, Hao Tang, Cheng Zhou Shanghai Ocean University (China) Field measurement of sinking characteristics of tuna purse-seine of different mesh sizes and its effect of catch performance
9:20	**Bent Herrmann**, Manu Sistiaga, Roger B. Larsen SINTEF Fisheries and Aquaculture (Denmark) New method to identify the optimal bar spacing for grids in shrimp trawl fisheries: the case of the deep-water shrimp (*Pandalus borealis*) in the North-East Atlantic
9:40	Discussion
10:00	Break
10:30	***Session 6: Fishing technology to eliminate vaquita bycatch from fisheries in the Upper Gulf of California (UGC)*** ***Facilitator:*** Enrique Sanjurjo (Mexico)
10:30	Daniel Aguilar, INAPESCA (Mexico) Results of the experiments with alternative fishing gear in the Upper Gulf of California -
10:50	Enrique Sanjurjo, WWF Upper Gulf of California Gulf of California Program (Mexico) Participation of Civil Society Organization for developing new gear to substitute gillnets from the Upper Gulf of California
11:10	Sara Königson, Peter Ljungberg and Sven-Gunnar Lunneryd, Swedish Agricultural University (Sweden) Experiences in the Baltic Sea for developing alternative fishing gear for gillnet fisheries in the Sea of Cortez
11:30	Tim Werner and Pablo Bordino, New England Aquarium (USA) Lessons learned from the prevention of Franciscana dolphin entanglements in small-scale gillnet fisheries
11:50	Lotte Kindt-Larsen, Finn Larsen, Technical University of Denmark (Denmark) Initiatives to protect porpoises in Denmark
12:10	Discussion, moderated by Michael Osmond
12:30	End-of-symposium remarks
13:00	***Field Trip***: See web page (return to hotel at about 9:30 pm).

	THURSDAY APRIL 28 HYATT REGENCY – BREAKOUT ROOMS
8:50	Announcement/Logistics
9:00	Topic group meeting
	TOR SpreadTrawl - Technological Innovation in Spreading Trawls (Paul Winger Bob van Marlen and Antonello Sala)

	TOR Non-extractiveSampling - Non-extractive fisheries sampling (Shale Rosen and Haraldur Einarsson) *TOR ChangeManagement* - Change Management in Fisheries (Steve Eayrs and Michael Pol)
	TOR ContactProbability - Contact Probability of Selective Devices (Daniel Stepputtis and Bent Herrmann)
10:40	Break
11:00	Topic group meeting (continued)
12:30	Lunch
14:00	Topic group meeting (continued)
15:30	Break
16:00	Topic group meeting (continued)
17:30	End
18:00	Visit and cocktail at Marista University of Merida Welcome remark by M.I. Miguel Baquedano Pérez, Rector of Marista University of Merida,
20:00	Return to Hyatt hotel

	FRIDAY APRIL 29 HYATT REGENCY
8:50	Announcement/Logistics
9:00	Country report summary (Barry O'Neill)
9:30	Report/summary: *TOR SpreadTrawl*
	Report/summary: *TOR Non-extractiveSampling* Report/summary: *TOR ChangeManagement* Report/summary: *TOR ContactProbability*
10:40	Break
11:10	Report/summary continues
	FTFB findings, conclusions and recommendations
12:30	Lunch
14:00	FTFB business: Election/selection of FTFB chair
	Next meeting - place and time for 2017 Suggestion for FTFB/FAST Joint session JFTAB FTFB three-year Terms of Reference
	New TORs for 2017 and beyond
	2017 ICES ASC proposal
	ICES Symposium proposal
	Announcements and other business
16:00	Adjourn

Annex 3. WGFTFB multi-annual terms of reference

The ICES-FAO **Working Group on Fishing Technology and Fish Behaviour** (WGFTFB), chaired by Haraldur A. Einarsson (Iceland) and Petri Suuronen (FAO), will meet to work on the following Terms of References (ToRs) and produce deliverables as listed in the following table for the years 2017 through 2019. This multiyear ToRs will be updated annually. WGFTFB will report on the activities by 25 June each year to SSGIEOM.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
A	Deliberate, discuss and synthesize recent research on topics related to: i) Designing, planning, and testing of fishing gears used in abundance estimation; ii) Selective fishing gears for the reduction of bycatch, discard and unaccounted mortality, especially as they relate to EU Landing Obligation; iii) Environmentally benign fishing gears and methods, iv) Improving fuel efficiency and reduction of emission from fisheries, and v) Summaries 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 technical manuals on current developments and innovations.	28, 29, 30, 31 primarily; others are possible (e.g. 11, 12, 27)	3 Years	ICES report
B	Organize a FAO-hosted FAO-ICES mini-symposium with thematic issues. Symposium themes will be determined at Year 2, and included in the updated ToR.	Under mutual agreement between ICES and FAO, FAO develops and leads a mini-symposium of relevant topics, while also continuing ICES commitments.	29, 30	Year 3	FAO report, ICES report
C	Deliberate, discuss and synthesize recent research on topics of mutual interest between WGFTFB and WGFAST	Every three years, WGFAST and WGFTFB meet for one day to share information on topics of mutual interest (JFATB).	28, 29, 30, 31	Year 1	JFATB report

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
D	Help organize an ICES-sponsored international fishing technology and fish behaviour symposium	The last similar symposium was ten years ago (2006).		Fall 2020 (outside scope of this Multiannual ToR)	Symposium and special issue in ICES JMS
E	Support survey working group with gear expertise support upon request	SSGIEOM has identified gear expertise gaps in survey working groups.	31	Year 1,2	Including possible survey trawl workshop

Summary of the Work Plan

Year 1	Produce the annual report; hold joint session with WGFAST; connect to survey WGs
Year 2	Produce annual report; Continue development of relationships with survey EGs
Year 3	Produce the annual report; organize FAO-ICES mini-symposium

Supporting information

Priority	The activities of WGFTFB will provide ICES with knowledge 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 living marine resources and other topics related to the performance of commercial fishing gears and survey gears.
Resource requirements	The research programmes that provide the main input to this working group already exist, and resources are already committed by individual institutions. The additional resource required to undertake activities in the framework of this group is negligible. However, each institution is encouraged to support participation of experts from their institution.
Participants	The group is normally attended by about 40–50 regular members and chair-invited members. Participation is about 70 - 90 in the year when FAO-ICES mini-symposium is held.
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 other groups of SSGIEOM, e.g. WGFAST, and the survey groups.
Linkages to other organizations	The WG is jointly sponsored with the FAO.