ICES - FAO WORKING GROUP ON FISHING TECHNOLOGY AND FISH BEHAVIOUR (WGFTFB; outputs from 2020 meeting)

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ICES International Council for the Exploration of the Sea
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Contents

i Executive summary

The Working Group on Fishing Technology and Fish Behaviour (WGFTFB) discusses and reviews research and practices of fishing technology and fish behaviour in relation to commercial and survey gears, and provides guidance for management including, inter alia, the impacts of fishing on the environment. The working group is jointly supported by the International Council for the Exploration of the Sea (ICES) and the Food and Agriculture Organization of the United Nations (FAO), which have fostered a fruitful working relationship in an international forum. WGFTFB also collaborates with the Working Group on Fisheries, Acoustics, Science and Technology (WGFAST) to facilitate the interdisciplinary exchange of knowledge and to foster cooperation.

Due to the COVID-19 pandemic, the group worked by correspondence in 2020 to produce this abbreviated collection of national reports describing activities in different countries. National reports are structured to give an overview of current and planned activities in the institutes and organizations of the county that are active in research in fishing gear and fish behaviour. They are an important tool to stimulate collaborative research by highlighting research themes and sharing of ideas that other countries might also benefit from. Current national reports cover a broad field of gear technology research, including research related to bycatch reduction of target and bycatch species (including ETP-species - endangered, threatened and protected species), minimizing the effect on the marine environment, pollution and energy efficiency.

ii Expert group information

Expert group name	ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB)
Expert group cycle	Multiannual
Year cycle started	2020
Reporting year in cycle	1/3
Chair(s)	Daniel Stepputtis, Germany (ICES chair)
	Antonello Sala, Italy (ICES chair)
	Pingguo He, Italy (FAO chair)
Meeting venue(s) and dates	20-24 April 2020, Bergen, Norway (Meeting cancelled, By correspondence)
	19-23 April 2021, Online Meeting
	TBD, TBD

1 Explanatory Notes on Meeting and Report Structure

ICES and FAO have had a fruitful working relationship on fishing capture technology and related fields for many years. The ICES Working Group on Fishing Technology and Fish Behaviour (WGFTFB) was given a global mandate in 2002 when FAO accepted the invitation of the ICES to form a joint Working Group with the new title ICES-FAO Working Group on Fishing Technology and Fish Behaviour (ICES-FAO WGFTFB). The primary objective of the ICES-FAO WGFTFB is the incorporation of fishing technology issues and expertise into management advice including, inter alia, the impacts of fishing on the environment (e.g. bycatch, unaccounted fishing mortality, habitat impacts, energy use, greenhouse gas emission).

As there was no physical nor virtual meeting in 2020, this report does not contain information about the collaborative work during the meetings (sessions, presentations, topic groups).

A substantial part of the work of WGFTFB and important source of information about the ongoing work of fishing gear scientists around the world are the national reports. Therefore, whereas no meeting was held, this report lists those national reports submitted for the period 2019 to 2020, but only few countries submitted reports.

2 National Reports

WGFTFB-members were asked prior to the meeting to prepare summaries of current and expected research related to the activities of the WG within their country. Nine national reports were received: Canada, France, Germany, Iceland, Ireland, Norway, Scotland, Spain and the United States of America.

This section lists the national reports submitted by WGFTFB members, alphabetically sorted by country name.

The contents of the individual national reports were NOT discussed by the group and not edited by chairs, and as such they do not necessarily reflect the views of the WGFTFB.

2.1 Canada

2.1.1 Contact person

Paul Winger, Paul.Winger@mi.mun.ca

2.1.2 Projects

2.1.2.1 Project: T90 Codend Selectivity for Redfish

Project Full Title: Evaluating the size selectivity of traditional and T90 codends in Canada's east coast redfish fishery

Project Timeframe: April 2018 – Dec 2019

Institution(s): Fisheries and Marine Institute; Marine and Freshwater Research Institute; Massachusetts Division of Marine Fisheries

Contact person: Paul Winger, Paul.Winger@mi.mun.ca

Summary: A covered codend experiment was conducted in Unit 1 (Eastern Canada) to compare the catch length composition of a regulated, diamond-shaped mesh codend with a 90 mm mesh opening to length composition for three different T90 codends with mesh sizes of 90, 100, and 110 mm. Results showed that the traditional codend was not size selective, catching greater than 97% of redfish over all length classes available. Compared to the traditional codend, the T90 codend (90 and 100 mm mesh) would retain 30% fewer undersized redfish (< 22 cm), while limiting reductions of legal-sized redfish to 16%. The T90 codend with 110 mm mesh would retain 50% fewer undersized and 40% fewer redfish larger than 22 cm. The T90 codend could therefore reduce the retention of small redfish.

2.1.2.2 Project: Aligned Rolling Footgear

Project Full Title: Reducing seabed impacts of bottom trawls in Canada's Arctic Ocean.

Project Timeframe: April 2018 – March 2021

Institution(s): Fisheries and Marine Institute; Nunavut Fisheries Association

Contact person: Paul Winger, Paul.Winger@mi.mun.ca

Summary: A 3-year project is currently underway to design and test novel footgear concepts to reduce seabed impacts of bottom trawls in Canada's eastern Artic. This is a partnership with factory freezer trawlers operating in NAFO Division 0A/B between Baffin Island and Greenland. Fisheries of interest include Northern shrimp and Greenland halibut. To date, novel designs have been conceived and evaluated using physical models in a flume tank. Full-scale prototypes will be tested at sea in 2020 and 2021.

2.1.2.3 Project: Moving Codend

Project Full Title: Developing a codend to increase selectivity and decrease discard mortality in the Newfoundland redfish fishery

Project Timeframe: Nov. 2018 – Nov. 2020

Institution(s): Fisheries and Marine Institute

Contact person: Shannon Bayse, Shannon.Bayse@mi.mun.ca

Summary: This project developed a moving codend with the goal of motivating redfish to escape out of a codend at depth. A flume tank test was performed to quantify the codends movement, and a small-scale sea trial was completed to measure size selectivity. Results show that placing a tarp on the posterior of a codend can lead to steady movement, and there is some indication that size selectivity was improved for redfish when compared to a non-moving codend.

2.1.2.4 Project: Semi-pelagic Trawl for Redfish

Project Full Title: Optimizing semi-pelagic trawling for Redfish in Unit 1

Project Timeframe: Sept. 2019 – Nov. 2020

Institution(s): Fisheries and Marine Institute

Contact person: Shannon Bayse, Shannon.Bayse@mi.mun.ca

Summary: In the 1990s, prior to the redfish moratorium in Unit 1 (Gulf of St. Lawrence), a popular trawl design to target redfish was a semi-pelagic design where the doors are on bottom, bridles are connected to the warps, and the trawl is off-bottom; the so-called "French Rigging". This project aims to re-establish and optimize this design with flume tank tests of a model, and sea trials of a full-scale trawl to optimize the design and quantify fish behaviour to the trawl. Tests at sea will be in summer 2020.

2.1.2.5 Project: Snow Crab Novel Stimuli

Project Full Title: Evaluating novel stimuli for the capture of snow crab

Project Timeframe: April 2019 – Jan. 2020

Institution(s): Fisheries and Marine Institute

Contact person: Shannon Bayse, Shannon.Bayse@mi.mun.ca

Summary: Snow crab pots made of luminescent twine were tested in Conception Bay, Newfoundland, CA to determine how soak time affects the capture rate of snow crab with

luminescent pots vs. traditional snow crab pots. An earlier study determined that long soak times did not show a change in catch rate when using luminescent twine, whereas short soak times had a significant increase in catch rate. However, this study had long soak times also associated with large catches and did not consider pot saturation as a potential reason for a lack of observable difference. This study compared the luminescent pots in a region where catch rates are low, enabling long soak times without concern of pot saturation. Results showed that catch rates were also increased with luminescent pots at long soak times (5-8 days).

2.1.2.6 Project: How Increased Luminescence Affects Snow Crab Capture

Project Full Title: Using luminescent twine to improve conservation goals in the Canadian snow crab pot fishery

Project Timeframe: Jan. 2020 – Jan. 2021

Institution(s): Fisheries and Marine Institute

Contact person: Shannon Bayse, Shannon.Bayse@mi.mun.ca

Summary: Using luminescent fibers in snow crab pot twine has been shown to increase the capture of snow crab. Here, we will test twine with x2 and x4 the amount of luminescence to see if increased luminescence can further increase the capture of snow crab in pots. Sea trials will take place in spring 2020.

2.1.2.7 Project: End-of-tow Sampling Biases in a Snow Crab Survey

Project Full Title: Assessing and correcting for end-of-tow biases in the southern Gulf of Saint Lawrence snow crab survey

Project Timeframe: July 2019 – Sept. 2020

Institution(s): Department of Fisheries and Oceans

Contact person: Tobie Surette, Tobie.Surette@dfo-mpo.gc.ca

Summary: Trawl swept area is used to standardize southern Gulf of Saint Lawrence snow crab survey catch data and produce estimates of annual biomass estimates on which quota levels are directly set. However, two sources of bias in the swept area estimates have been highlighted: possible asymmetry in the trawl configurations and the existence of latent phase of trawling after active trawling is supposed to have ended. Acoustic trawl monitoring probes, Doppler water current probes, depth-pressure probes and tilt angle probes are affixed to the trawl and used to characterize individual trawl behaviour and explore correctives for the identified biases.

2.1.2.8 Project: NL-DFO Multi-Species Survey Trawl

Project Full Title: Modifications to the Campelen 1800 Shrimp Survey Trawl

Project Timeframe: December 2019 – December 2021

Institution(s): Department of Fisheries and Oceans

Contact person: Truong Nguyen, Truong.Nguyen@dfo-mpo.gc.ca

Summary: This project aims to make our survey trawl more user friendly and less susceptible to damage. This increases cost-effectiveness, improves productivity at sea (e.g. optimizing use of vessel time when on program, i.e. reduce overall repair time) as well as the financial and human resources that are required to maintain the surveys. The proposed trawl modifications will be evaluated throughout the numerical simulations, flume tank testing, and comparative fishing.

2.1.2.9 Project: Minimizing groundfish bycatch in the redfish fishery

Project Full Title: Building a sustainable redfish fishery in the Gulf of St. Lawrence: minimizing groundfish bycatch and seabed impacts

Project Timeframe: April 2018 – December 2020

Institution(s): Fish, Food and Allied Workers Union

Contact person: Erin Carruthers, ecarruthers@ffaw.ca

Summary: A series of side-by-side trawl comparisons are being used to test modifications to minimize environmental impacts, such as reduced seabed impacts and unwanted groundfish bycatch, while maintaining catch rates of targeted redfish species. Additionally, midwater trawls are being fished concurrently to determine redfish catch rates relative to bottom trawl gear. Initial results include comparable redfish catch rates from bottom trawls fished with semi-pelagic doors compared to standard bottom doors. Midwater trawl catch rates were highly variable but overall catch rates were comparable to bottom trawl during the winter 2020 fishery. Ongoing field trials during May-September 2020 will be used to determine seasonal differences in catch rates of target and bycatch species.

2.1.2.10 Project: Development of an Efficient Redfish Trawl

Project Full Title: Development of an efficient redfish trawl to mitigate bycatch and improve size selectivity

Project Timeframe: May 2017- March 2020

Institution: Merinov

Contact person : Damien Grelon, Damien.grelon@merinov.ca

Summary: The main objective of this project was to develop an adaptable trawl usable as a bottom, semi-pelagic and pelagic rigging for catching redfish. Sub-objectives included undersized fish exclusion and bycatch reduction, with lowest possible seafloor contact. A trouser French-rigging model was successfully tested. Flexible grid devices, mesh sizes and orientations, in the extension and codend were also assessed. First results were interesting but mixed due to limited sea trials and a unimodal small fish size frequencies harvested.

2.1.2.11 Project: Charactering Bottom Contact of Trawls

Project Full Title: Characterization of the bottom contact of the different redfish trawls

Project Timeframe: May 2017- March 2020

Institution: Merinov

Contact person: Marie-Claude Côté-Laurin, marie-claude.cote-laurin@merinov.ca

Summary: This project will document with different technologies and direct or indirect indicators the degree, frequency and duration of bottom contact of the three types of trawls that might be authorized in a future redfish fishery (bottom, semi-pelagic, pelagic trawls) in the Gulf of St. Lawrence. The information gathered is aimed to help fishermen in using different tools to follow and control their trawls during fishing activities according to the regulations, and to provide DFO with some estimates of the impacts of the trawls on the bottom and benthic communities in order to improve decision-making.

2.1.2.12 Project: Improving Safety

Project Full Title: Safety design criteria of working stations like pot hauler and supporting rack onboard lobster boats in Quebec LFA

Project Timeframe: April 2019- March 2020

Institution: Merinov

Contact person: Francis Coulombe, francis.coulombe@merinov.ca

Summary: 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, we analysed the risks and determined factors involved in over-board falls; we documented collective and individual prevention solutions that can be adapted to lobster boats. We identified with the most promising risk reduction scenarios. In 2015, we developed, tested at-sea, and implemented practical integrated technical solutions for the pot hauler and the supporting fishing lines rack. Both of these are used by crewmen for easing their work. Attention has been paid to reduce rope entanglement risks and body efforts when hauling and launching the fishing gear. Results are currently under analysis.

2.1.2.13 Project: Evaluating Weak Links

Project Full Title: Entanglements of right whales – Weak links for snow crabs fisheries

Project Timeframe: August 2019- November 2020

Institution: Merinov

Contact person: Jerome Laurent Jerome.laurent@merinov.ca

Summary: This feasibility study aims to measure tensions in the vertical ropes of snow crab traps, in all fishing situations encountered by fishermen in the Gulf of St. Lawrence. The data collected will be used to determine the minimal breaking load of the rope for use without risk of trap loss. Other mounting configurations of the fishing gear will be tested to try to decrease the tension in the vertical rope. These data will be compared with theoretical tensions that a right whales would impose on the rope in its efforts to become disentangled. In case of compatibility between the data, the next step will be to size and configure a weak link system and carry out sea trials in fishing situations.

2.1.2.14 Project: Retrieving Lost Snow Crab Pots

Project Full Title: Ghost Gear, detect and recovery lost or abandoned fishing gears

Project Timeframe: September 2019 – March 2023

Institution: Merinov

Contact person: Stéphanie Pieddesaux, stephanie.pieddesaux@merinov.ca

Summary: As part of a 4-year project started in 2019, Merinov and its partners are working on ghost gear issues. They are developing methods for detecting and recovering snow crab pots lost or abandoned by fishermen.

2.1.2.15 Project: Improving Catch Quality

Project Full Title: On board redfish catch quality enhancement with a new pelagic trawl by development of conservation methods

Project Timeframe: October 2017- December 2020

Institution: Merinov

Contact person: Lise Chevarie lise.chevarie@merinov.ca

Summary: The upcoming reopening of the commercial redfish fishery in the Gulf of St. Lawrence (eastern Canada) is generating renewed interest in the Magdalen Islands. Before the 1994 commercial fishing moratorium, the quota-share allocated to the Magdalen islanders was 75% of the Quebec total. This project aims to test new fish catch storage and handling techniques. Single trays will be compared to in ice bulk storage. The gear will be a semi-pelagic trawl. Sea trials will be carried out in 2020.

2.1.2.16 Project: N-Viro Scallop Dredge

Project Full Title: Innovative sea trials of a sustainable N-viro dredge in a giant scallop (*Placopecten magellanicus*) fishery

Project Timeframe: August 2019- May 2020

Institution: Merinov

Contact person: Lise Chevarie, lise.chevarie@merinov.ca

Summary: Giant scallop fishermen from Magdalen Islands (Quebec, Canada) are currently the using Digby-style scallop dredge. In order to further comply with the precautionary approach principle and reduce energy costs, they want to assess the performance of the new N-Viro dredge. This gear is successfully used abroad. This fishery is managed by a limited number of licenses and few fishing days as well. So, an efficient drag is needed. At-sea comparative tests (twelve fishing days) has been carried between both dredge types. Data analysis is in progress.

2.2 France

2.2.1 Contact person

Larnaud Pascal, Ifremer, pascal.larnaud@ifremer.fr

2.2.2 Summary

- Improvement of trawl selectivity on commercial vessels in the Bay of Biscay and Eastern Channel (respectively OPTISEL - SELUX).
- Discards survival (DREAM);
- Alternative fishing gears: design of fish pots (BAITFISH) based on target fish species' behaviour and ecology; design of "off bottom" doors for bottom trawling (REVERSE); Giving Artificial Monitoring intElligence tO Fishing TRAWLS (GAME OF TRAWLS).

2.2.3 Projects

2.2.3.1 Project: Development, test and OPTImisation of 3 fishing gears to improve SELectivity (OPTISEL)

Project Full Title: Development, test et OPTImisation of 3 fishing gears in the Bay of Biscay to improve SELectivity : Nephrops grid, monkfish grid and swordfish longline.

Project Timeframe: January 2018 – May 2020

Institution(s): AGLIA (Association du Grand Littoral Atlantique), Ifremer and Fishing committees

Contact persons: Quiterie Sourget, sourget.aglia@orange.fr, AGLIA (Association du Grand Littoral Atlantique), Pascal Larnaud, pascal.larnaud@ifremer.fr, Sonia Méhault, sonia.mehault@ifremer.fr

Link(s): https://www.aglia.fr/optisel/

Summary:

In the continuity of the REDRESSE project, the OPTISEL project still aims to improve the selectivity in the fisheries of the Bay of Biscay in order to decrease discards. It is funded by the European Maritime and Fisheries Fund (EMFF) and by « France Filière Pêche ».

The work on Nephrops grids in the REDRESSE and GRILLETINE projects showed satisfactory results on ergonomics (no problem for handling) and selectivity (significant reductions in Nephrops discards from -20% to -40%, and small commercial losses). Different types of grids have been tested and a polyurethane grid made of 6 articulated pieces (Figure 1) has produced the best results, both from the point of view of the mechanical resistance and the escapements of small *Nephrops*. This grid was tested on 9 commercial vessels in the Bay of Biscay in 2019. The good ergonomy and mechanical resistance was confirmed (no damage), as well as the preliminary results on Nephrops selectivity. Some variability was still observed depending on the size of the boats and on their fishing practices.

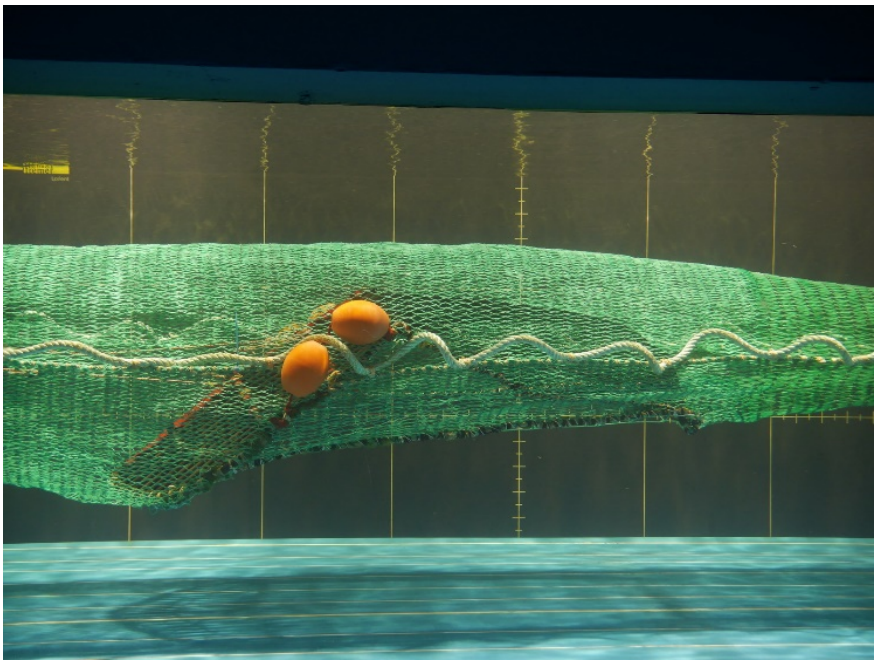

Figure 1: Test of the articulated *Nephrops* grid in Lorient Flume tank

2.2.3.2 Project: Improvement of selectivity of trawlers with lighting devices (SELUX)

Project Full Title: Improvement of selectivity in artisanal trawlers fishery in the Channel and South of North Sea via the use of lighting devices

Project Timeframe: January 2019 – January 2021

Institution(s): FROM Nord (Producer Organization), private companies SafetyNet and Le Drezen

Contact person: Loeiza Lancelot, l.lancelot@fromnord.fr, Pascal Larnaud, pascal.larnaud@ifremer.fr , Franck Coppin, Franck.Coppin@ifremer.fr

Link(s): https://wwz.ifremer.fr/Espace-Presse/Communiques-de-presse/Tests-en-cours-pour-les-filets-de-peche-lumineux

Summary:

The objective of the SELUX project is to test the association of well-known selective devices (square mesh or T90 panels or cylinders) with lighting equipment in order to improve their selectivity for different target species, in particular whiting.

The devices are made of fluorescent twine (Brezglow, Le Drezen company), or waterproof LED (SafetyNet Pisces system), organized into different configurations (Figure 2).

Preliminary sea trials were carried out in April and May 2019 on professional fishing vessels in the Eastern Channel – South of North Sea, with video observation of fish behaviour in contact with the devices and with small meshes covers. The preliminary results have shown an effect and enabled to define the position of the lamps and of the fluorescent twine for the catch comparison tests coming in June 2020.

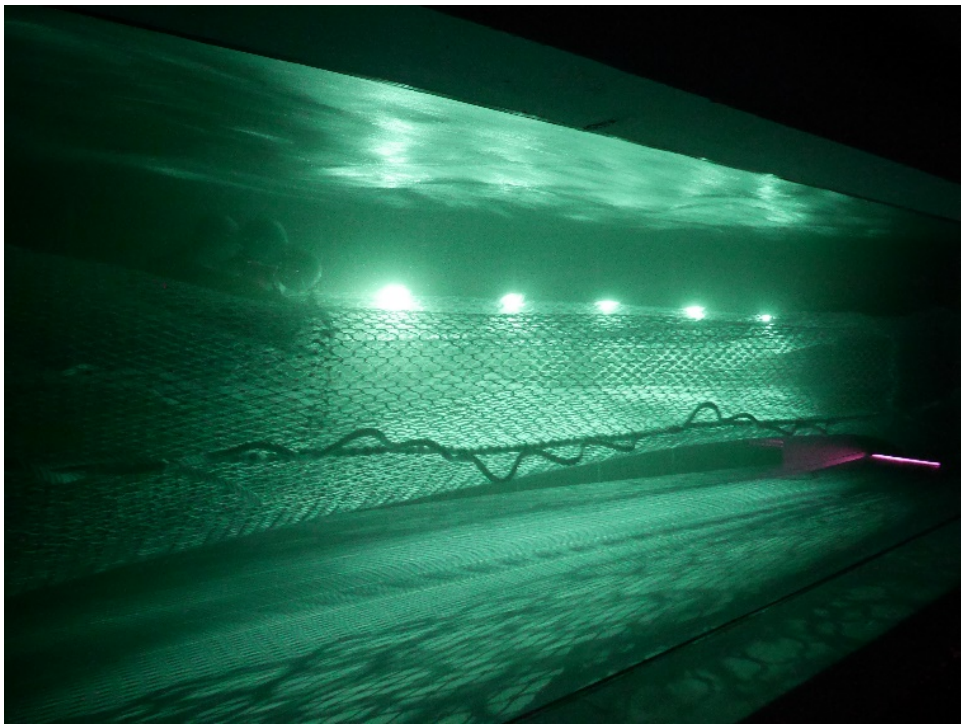

Figure 2: Preliminary trials with SafetyNet lamps in Lorient flume tank

2.2.3.3 Project: Evaluation of the fate of discard (DREAM)

Project Full Title: Devenir des REjets : de l'Air au fond de la Mer

Project Timeframe: January 2019 – December 2021

Institution(s): Ifremer, PELAGIS, MNHN and the COREPEM (Fishing Committee of the Pays de la Loire Region)

Contact persons: Dorothée Kopp, dorothee.kopp@ifremer.fr, Sonia Méhault, sonia.mehault@ifremer.fr

Summary:

The aim of the DREAM project is to study discard survival from a broad point of view. In 2019, non-commercial invertebrate's survival has been tested in captivity. 600 individuals from six different benthic invertebrate genera were collected in commercial conditions in the Bay of Biscay, aboard a 10.95 m-long bottom trawler rigged with a single otter trawl (20 m headline), and put in water tanks with continuous flow. Overall, the observed survival after 100-130 hours and the predicted survival via mixture models (SMMs) were very high (>93%) for Asterias rubens, *Aphrodita aculeata*, *Buccinum undatum* and *Pagurus*. Survival of *Maja brachydactyla* was lower though still high (>80% overall), and *Atelecyclus undecimdentatus* was more vulnerable to trawling and handling, with ~50% of survival. No biotic or abiotic parameters were found highly correlated to survival, except injury class for *M. brachydactyla* and *A. undecimdentatus*. This study shows an overall high survival but highlights the fact that otter trawl fisheries may differentially affect the discarded benthic invertebrates.

2.2.3.4 Project: Behaviour, performAnce, Impacts of poTs FISH (BAITFISH)

Project Full Title: Behaviour, performAnce, Impacts of poTs FISH

Project Timeframe: January 2018 – December 2020

Institution(s): Ifremer, South Brittany University, Fishing committee of Finisterre

Contact person: Sonia Méhault, sonia.mehault@ifremer.fr

Summary:

The environmental awareness of the French fishing industry makes it inclined to adopt more and more sustainable fishing gears. In that context, fish pots show a growing interest from fishermen. However, most of the attempts to use standard commercial pots failed to catch economically valuable fish species. This experiment aimed at developing a fish pot concept specifically based on target species behaviour in coastal waters of the Bay of Biscay, France. First, the concertation led with fishermen showed the black seabream as the main species of interest. The specifications of the pot to be developped with respect to the ergonomical, environmental and legislative constraints were also defined. Various baits were tested using Baited Remote Underwater Video (BRUV). Bait feeding behaviour of black sea bream was caracterised using an ethogram. The conception process of the pot was led step by step by (1) identifying the most attractive bait, (2) testing gradually a pot structure appropriated to black seabream behaviour, (3) identifying and avoiding potential competitors, (4) assessing pot selectivity and (5) evaluating physical impact on sea floor. The experiment led to a proto-type of pot tested onboard commercial fishing vessels, which provided an overall cost/benefit of pot fishing in French coastal waters.

2.2.3.5 Project: "off bottom" doors for bottom trawling (REVERSE)

Project Full Title: "off bottom" doors for bottom trawling

Project Timeframe: January 2017 – May 2020 (extension requested)

Institution(s): Ifremer, Morgère Company, French Fishermen National Committee (CNPMEM)

Contact person: Benoît Vincent, benoit.vincent@ifremer.fr

Summary:

The REVERSE project aims at adapting bottom trawling with off bottom door. The project has started with a theoretical stage to design doors with higher efficiency using CFD tools and flume tank trials. A six-component force balance was used in Lorient flume tank to validate CFD results. First tests at sea with professional fishers revealed no particular technical problem, but we had to face a lack of volunteers. Tests will continue until the end of the project particularly with twin trawls rigging. REVERSE project is funded by the European Maritime and Fisheries Fund (EMFF) and by the « France Filière Pêche » association.

2.2.3.6 Project: Giving Artificial Monitoring intElligence tO Fishing (GAME OF TRAWLS)

Project Full Title: Giving Artificial Monitoring intElligence tO Fishing

Project Timeframe: January 2019 – December 2021

Institution(s): Ifremer, South Brittany University, MARPORT, Fishing committee of Morbihan

Contact person: Julien Simon, julien.simon@ifremer.fr

Summary: Some trawl fisheries are still recording high levels of bycatch despite the numerous selectivity projects conducted in the recent years. The main issue is that trawlers are towing their fishing gears for hours without knowing if what is actually entering their trawls is what they are targeting. Moreover, inside trawls the fish often adopt a behavior which consists of not coming into contact with the meshes, which makes the selective devices inefficient.

In the GAME OF TRAWLS project (Giving Artificial Monitoring intElligence tO Fishing TRAWLS) we propose to adapt the technological advances made in recent years in the field of artificial intelligence to fishing trawls. This project will propose several approaches, including computer vision and deep-learning to be able to detect and identify in real time the species that enter the fishing gear. Such systems could allow fishermen to detect in real time high abundance of bycatch in their trawls so they could operate an escape device (diversion hatch, bright flash, acoustic signals ...) or they could change of fishing area.

2.3 Germany

2.3.1 Contact person

Daniel Stepputtis, Thünen Institute of Baltic Sea Fisheries, daniel.stepputtis@thuenen.de

2.3.2 Summary

In Germany, research related to fishing gears was mainly conducted by the Thünen Institute of Baltic Sea Fisheries (see report from university of Rostock below). The focus of the research in 2019 was

- Understanding and improving of trawl selectivity, incl.
  - Species-selection devices in beam trawl shrimp fishery (cruise No SO767, 09/2019; cruise No SO769, 10-11/2019)
  - Development and testing of cod bycatch reduction devices for flatfish fisheries in the Baltic Sea (cruise No CLU340, 11-12/2019; cruise No SO773, 02/2020)
- Alternative technologies to mitigate the environmental impact of fishing activities, incl.
  - Reduction of plastic waste (Dolly Ropes) from the brown shrimp fishery through gear modifications (cruise No SO758, 01/2019; cruise No SO767 09/2019; cruise No SO769 10-11/2019)
- Bycatch reduction of marine mammals and birds in gill nets, incl.
  - modification of gillnets
  - improvement and test of alternative fishing gears pots and traps

Additionally, the fisheries and survey technology working group of the Thünen Institute is currently working on different technical devices to support fishery in general and fishery technological research in particular. Examples are

- Open Scientific Measurement Board (OpenSMB), a scientific Open Source data acquisition system to be used in fisheries sciences
- Infrared Fish Observation iFO, an Open Source camera system for 24/7 video surveillance

2.3.3 Projects

2.3.3.1 Project: Innovative selectivity devices for bycatch reduction in North Sea beam trawl fishery targeting brown shrimp

Project Full Title: Innovative selectivity devices for bycatch reduction in North Sea beam trawl fishery targeting brown shrimp

Project Timeframe:

Institution(s): Thünen Institute of Baltic Sea Fisheries

Contact person:

Juan Santos, juan.santos@thuenen.de and

Uwe Lichtenstein uwe.lichtenstein@thuenen.de

Daniel Stepputtis, daniel.stepputtis@thuenen.de

Link(s):

Summary:

09/2019. Experimental catch-comparison data collected onboard FRV "Solea" cruise No SO767. Next "Solea" cruise No SO769 resumed the investigations from an engineering perspective, with the aim of assessing mechanical properties of the devices compared, and identifying opportunities for improvements.

The North Sea shrimp fishery takes place in shallow coastal waters, especially in the Danish, German and Dutch 'Wadden Sea'. To a lesser extent, it also occurs in coastal waters of Belgium, France and the UK. The peak of the brown shrimp fishery season occurs in late summer-autumn (August-October) when brown shrimp migrate to shallower waters in the southern North Sea (Wadden Sea), an area classified as important nursery areas to several marine fish species. Especially during the reproductive season, fish of age 0+ are unintentionally caught in the fishery. The international project DISCRAN ran between 1998 and 2001 to address the bycatch problem by technological means. The project focused on developing and testing two bycatch reduction device concepts – sorting grids and sieve-nets. Each country developed its own designs that were subsequently tested in their respective fishing grounds. In general, both devices resulted in effective bycatch reduction of fish species larger than ~10 cm. As a consequence, fishermen were required to use either grids or sieve-nets in their trawls, whereas sieve-nets were preferred by the fishermen due to practical reasons (e.g. the reluctance to use rigid devices).

Currently, sieve-nets with mesh openings in the range of 50-70 mm are being used in the fishery. However, practical implementation revealed that the performance of the device can be hampered by extrinsic factors such as catch composition, clogging, etc., especially in seasons and/or fishing grounds with large amounts of bycatch species available for the gear. In such scenarios, clogging of the sieve-net is likely to occur due to gilled fish or entanglement of invertebrates or seaweed, leading to significant losses of marketable shrimps. Unclogging the device at sea is difficult for the crews due to the inner montage in the beam trawl.

Based on the mentioned problems, the need was identified to resume the investigations of the DISCRAN project in the search for technological alternatives to the currently implemented sieve-nets and grid devices.

One of the research topics addressed during the research cruise No. SO767 (09/2019) onboard the German FRV "Solea" involved initial experimental fishing with the so-called sieve-mat, a species bycatch-reduction device alternative to sieve-nets developed by Dutch fishermen. The sieve-mat is a net panel connected to the beam and the ground rope, covering the entire mouth area of the

trawl. Dutch researchers reported that the sieve-mat is easier to clean at sea than sieve-nets due to its montage at the entrance of the trawl. Reports from the Dutch industry also indicate that the sieve-mat might be at least as efficient as sieve-nets in reducing bycatch.

To assess the performance of the novel device, we conducted an experiment in which catches from a test trawl (mounting the sieve-mat) were compared to those catches from a control trawl (mounting a standard sieve-net). Twin-trawl facilities onboard allowed direct catch comparison by the paired-gear method. Six different sieve-mat specifications were tested during 41 experimental hauls. In general, the performance of sieve-mat to reduce bycatches is comparable to that obtained with the sieve-net (Figure 3 left). However, fewer catches of the targeted brown shrimp were obtained with the test trawl (Figure 3 right). Such differences were reduced progressively with improved -mat specs developed onboard. From this first experience using sieve-mat, we concluded that the performance of the sieve-mat can largely vary with small changes in the rigging of the device. Further tests need to be conducted to improve brown shrimp catchability and the understanding of the device functioning.

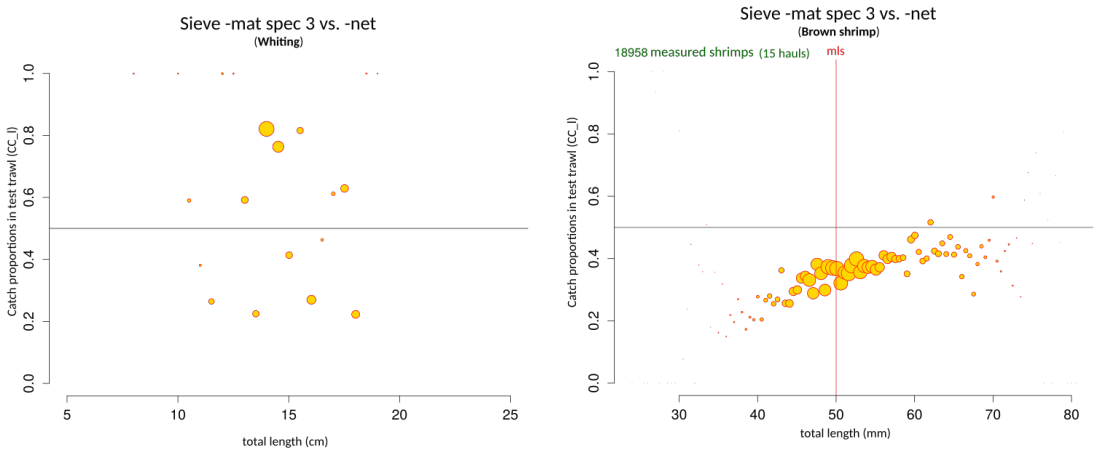

Figure 3: Catch proportion by length class of whiting (left) and brown shrimp (right) in the test gear mounting sieve-mat Spec 3, relative to the total catch. The vertical red line in the right figure shows approximate minimum commercial size of brown shrimp.

2.3.3.2 Project: COD EXcluders (CODEX)

Project Full Title: Technical approaches to avoid cod catches in Baltic Sea trawl fisheries

Project Timeframe:

Institution(s): Thünen Institute of Baltic Sea Fisheries

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Daniel Stepputtis, daniel.stepputtis@thuenen.de

Link(s):

http://www.thuenen.de/bycatch

Summary:

11-12/2019; 02/2020. Selectivity trials conducted during cruises FRV "Clupea" No 340 (28.11.-19.12.2019) and FRV "Solea" No 773. (02.02.-14.02.2020) to assess the performance of three different cod- bycatch reduction devices for Baltic flatfish fisheries. The devices were developed by the Thünen Institute of Baltic Sea Fisheries in collaboration with Baltic fishers and netmakers. Sea trials were conducted using the paired-gear method. The release efficiency provided by each device was assessed for the most frequent demersal Baltic species.

The Baltic cod quotas have been on the decline since 2014, and the trend continues with a sharp reduction for 2020 (60% less for Western stock and 92% less for the eastern stock). This scenario has raised questions on how to better utilize the remaining fishing opportunities in the Baltic Sea. It is of particular interest to answer the question on how to exploit healthier flatfish stocks avoiding limited cod quotas from choking normal fishing operations. Recently, the European Commission (EU) requested information from ICES on how to avoid the impact of limited cod quotas on fisheries targeting other species. Among other solutions, fishing technologists from Denmark (DTU-Aqua), Sweden (SLU) and ermany (Thünen) jointly presented a set of bycatch reduction devices to avoid cod catches in flatfish fisheries. The devices proposed were classified based on their basic functioning principle; 1) mechanical selectivity devices that take advantage of differences in morphology between cod and flatfish, 2) selectivity devices utilizing fish behaviour to sort and exclude species and 3) selectivity devices which combine the strategies 1) and 2).

The cruises FRV "Clupea" No 340 and FRV "Solea" No 773. (02.02.-14.02.2020) were used to develop and test three different behavioural-based BRD concepts: CODEX, ROOFLESS and ROOFLESS+STIPED (Figure 4 - Figure 6). The devices were developed by the Thünen Institute of Baltic Sea Fisheries in collaboration with Baltic fishers and netmakers from Rofia-Kloska. The three devices were mounted (one at a time) in the so-called NEMOS-device, a multi-purpose 2-4-2-panel net section located between the codend and the trawl body. The special design of NEMOS enables easy installation and removal of the selection devices described above. Such modularity provided a large degree of flexibility to switch among BRDs during the experiments.

Results obtained during the sea trials show that it is possible to reduce the cod bycatch in flatfish fisheries by applying a simple and adaptive technical modification in front of the codend. Applying ROOFLESS-175 - the simplest concept among the four designs tested - resulted in the best tradeoff between cod reduction and catchability of flatfish. First trials with ROOFLESS-175 during "Clupea" cruise led to a significant reduction in cod catches (75%) and relative low (~10%) but not significant catch reduction of plaice and dab. On the other hand, a higher catch reduction (~37%) was observed for the less abundant flounder. Concerns regarding flounder catch losses were clarified during "Solea" trials on fishing grounds with higher flounder abundance. In these trials, relative catch losses of flounder were largely reduced to 10%, the same value obtained for plaice and dab during the previous "Clupea" trials. Even though trials from both cruises were

conducted on different fishing conditions (vessel, trawls, fishing grounds and depths), the relative reduction of cod catches was equivalent (75%), even if the trails were performed with. These results represent empirical proof on the robustness of the selective properties of the ROOFLESS-175 device.

Following the experiments conducted with behavioural-based BRDs described above, It was planned to test a number of innovative codends specifically designed to avoid cod catches by mechanical means (strategy 1) during a research cruise planned for March 2020. This cruise had to be cancelled due to measures taken to address the Covid-19 pandemic. It is expected to conduct initial tests on short term after relaxation of Covid-19 preventive measures.

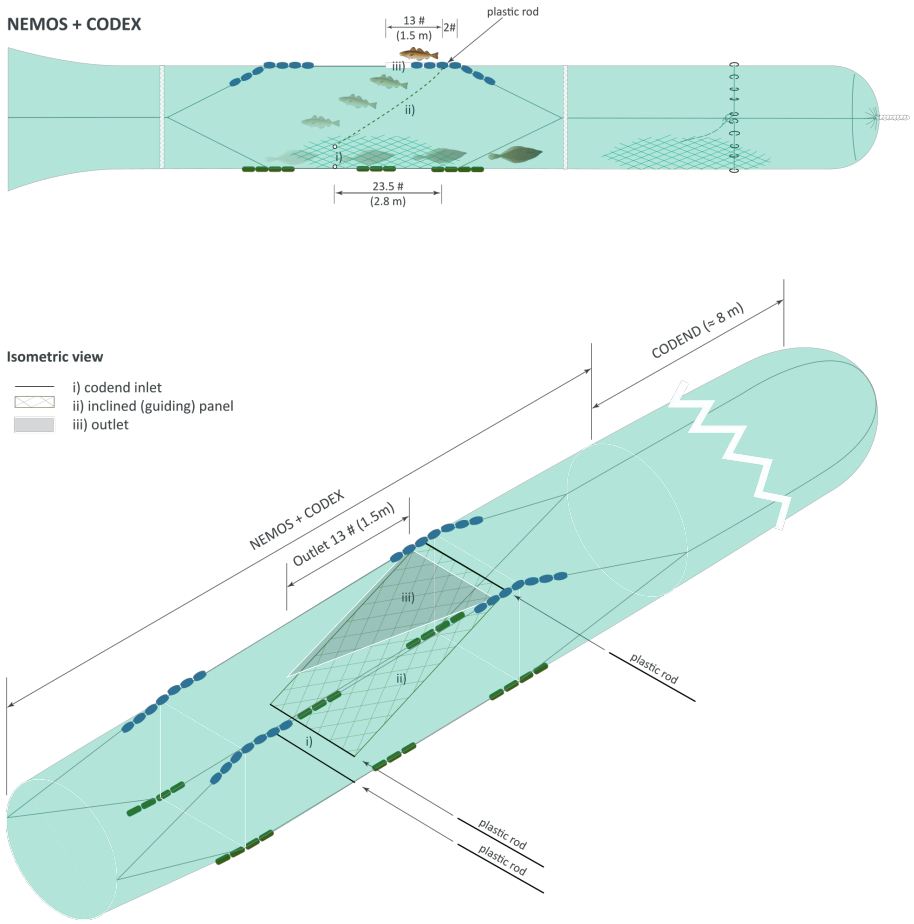

Figure 4: CODEX (COD EXcluder) consists of three elements: i) codend inlet, ii) inclined (guiding) panel and iii) outlet. Top: side view of the device showing the intended species selective principle. Bottom: Isometric view showing montage details of the device.

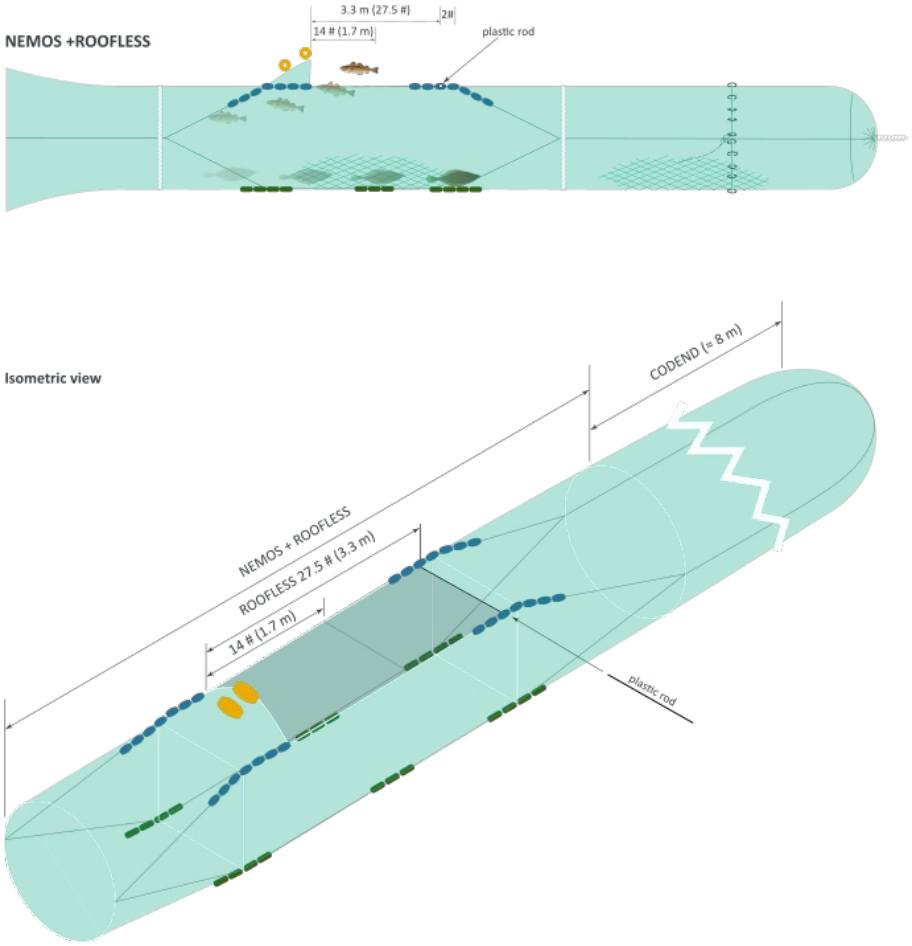

Figure 5: ROOFLESS device: bycatch reduction device mounted in NEMOS to reduce the catch of cod in flatfish fisheries. This gear adaptation involves removal of part of the top panel of NEMOS device (tested in two configurations with window lengths of 330cm and 175cm), as well as a lifted top panel section in front of the open window. The device provides a wide, net-free open window that could be used to escape by cod in its way to the codend. Top: side view of the device showing the intended species selective principle. Bottom: Isometric view showing montage details of the device.

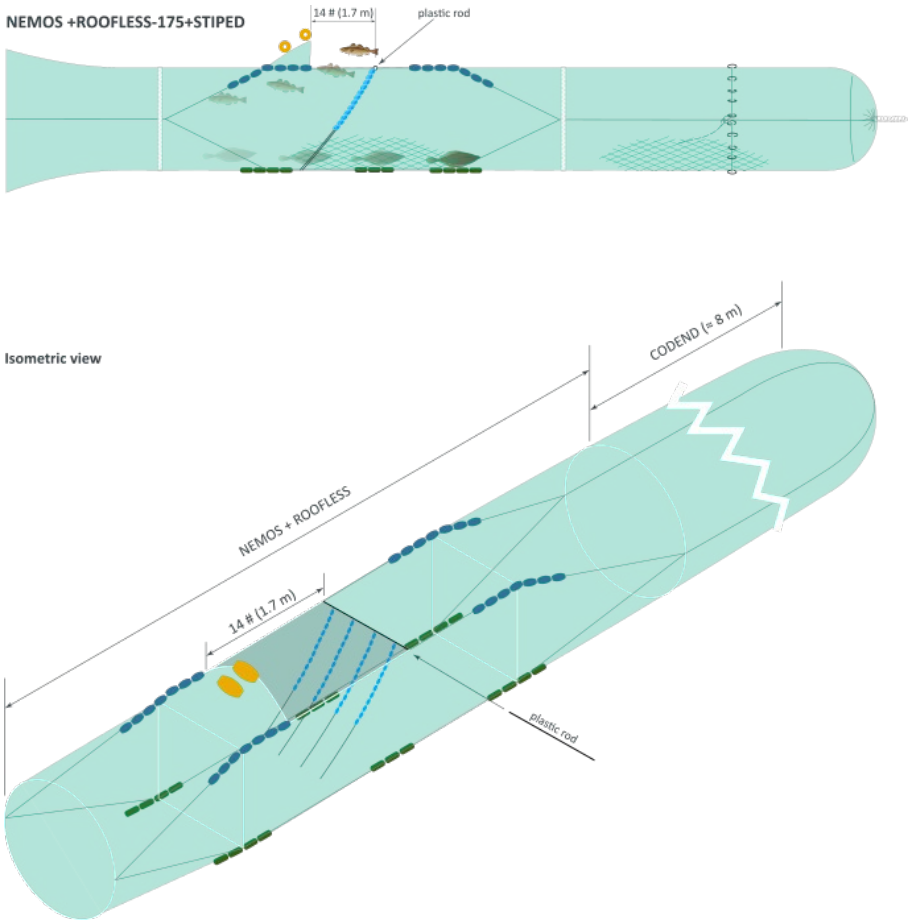

Figure 6: ROOFLESS+STIPED device: bycatch reduction device mounted in NEMOS to reduce the catch of cod in flatfish fisheries. This gear modification includes i) a removed section of the top panel of NEMOS (tested in configuration with a window length of 175cm), ii) a lifted top panel section in front of the open window and iii) STIPED stim-lating ropes. Top: side view of the device showing the intended species selective principle. Bottom: Isometric view showing montage details of the device.

2.3.3.3 Project: DRopS – Dolly Rope Supension

Project Full Title: Reduction of plastic waste from beam trawl fishery through gear modifications

Project Timeframe: Jan 2018 – December 2020

Institution(s): Thünen Institute of Baltic Sea Fisheries

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Link(s): www.thuenen.de/en/of/projects/fisheries-and-survey-technology/reduction-of-plastic-waste-from-the-brown-shrimp-fishery-through-gear-modifications-drops/

Summary:

To protect the bottom side of beam trawls (targeting sole or brown shrimp), the trawl is often equipped with abrasion protection. Various materials can be attached to the meshes of the gear in order to prevent abrasion of the material on the seabed - especially of the codends.

One of the most common materials used as scuff protection in North Sea beam trawl fisheries are the so-called „Dolly Ropes“. These are Polyethylene ropes (PE ropes), which are cut to size by the fishermen and woven into the net material. During fishing, the Dolly Ropes fray very easily and parts of it break off. According to the Dutch project DollyRopeFree (www.dollyropefree.com), 10 to 25% of the material is torn off within the first two weeks of usage. After this time, the remaining cords become tangled or entangled, reduce their flexibility and cause sand and gravel to clog. As a result, the remaining dolly ropes are replaced. Whereas the DollyRopeFree-project mainly focused on alternative materials, the German project DRopS aims to develop and test trawl gear modifications that reduce or prevent the contact of the gear with the seabed, thus making the use of Dolly Ropes as abrasion protection superfluous. Initially, the project focuses on the shrimp fishery in the North Sea.

During the project, four different approaches are investigated

1. Change of cutting of the gear: The cutting of the beam trawl may provide opportunities to further lift the codend off the ground. So far, side net panels (wedges) are installed between the upper and the lower net panel, which are aligned towards the seabed. In this project, side panels will be tested, which are oriented upward, so that the distance between the seabed and the gear, in particular the codend, increases (Figure 7). The catch comparison on the cruise SO758 (FRV “Solea”, 01/2019) showed that with the ascending trawl 2% more brown shrimp were caught than with the conventional trawl.

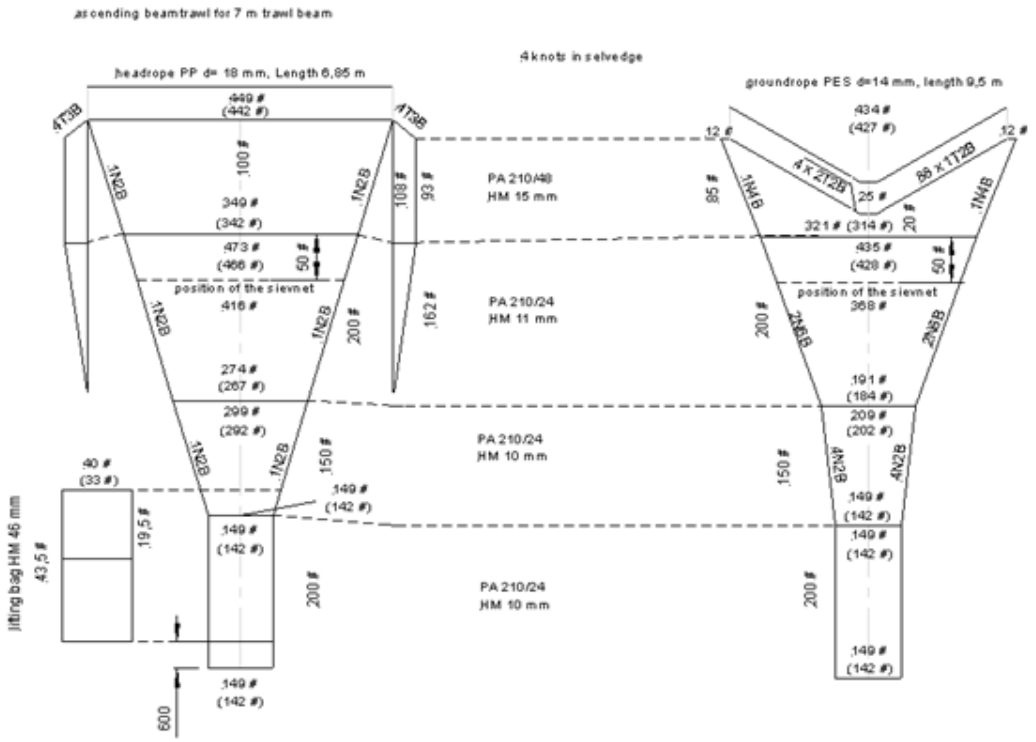

Figure 7: Cutting plan of the tested ascending beam trawl.

2. Achieving a constant cylindrical shape of the codend, and thus avoiding ballooning of T0-codends when the catch accumulate. Two strategies were tested:
   a) Use of ring reinforcements (strengthening ropes) and thus preventing increased diameter of the codend when the catch accumulates (Figure 8).

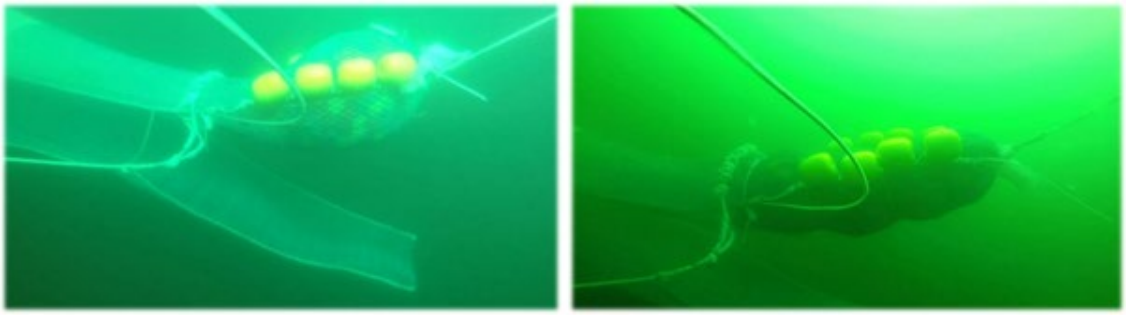

Figure 8: Left: Codend in pear shape without ring reinforcements. Right: Codend in a cylindrical shape with four ring reinforcements

   b) Orientation of the meshes: It is known (e.g. from previous experiments in the CRANNET project) that the orientation of the mesh material has a significant influence on the shape of the codend during the catch process. Meshes in T90 but above all meshes in T45 orientation reduce the perimeter increase of the codend as the catch size increases in the codend.

3. Testing of hydrostatic and hydrodynamic floating devices: To keep the codend off the sea bottom, several setups using hydrostatic (e.g. buoys) and hydrodynamic devices (kites) were tested to identify optimal configuration (Figure 9).

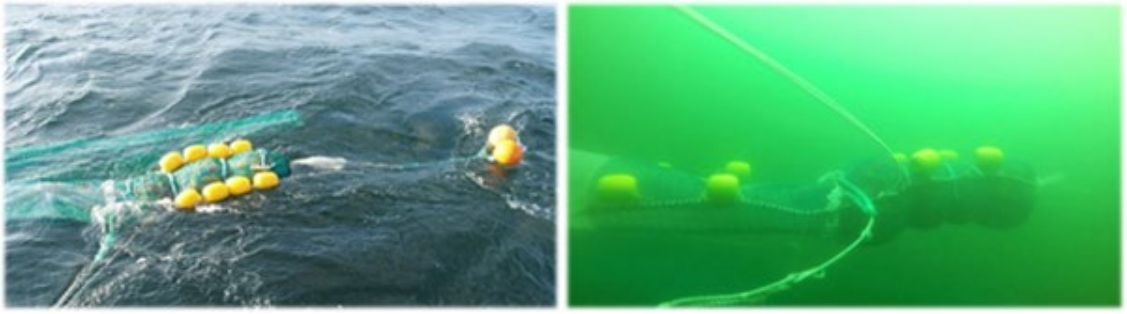

Figure 9: Codend floats and codend buoy. Right: Additional floats in front of the codend

4. Reduction of the catch of heavy material: The codend is also pulled down by catching heavy organisms (e.g. clams and sea urchins) or heavy material (e.g. stones and sand). Accordingly, one approach is to reduce the amount of these heavy materials - especially as they are unwanted bycatch. Several options are possible, such as:
   a) Benthos Release Panel (BRP). These have been tested in 2018 and 2019 but did not work as anticipated. A more radical approach using netting with big meshes in the under panel of the trawl has also been tested but needs to be revised to work as desired (Figure 10).

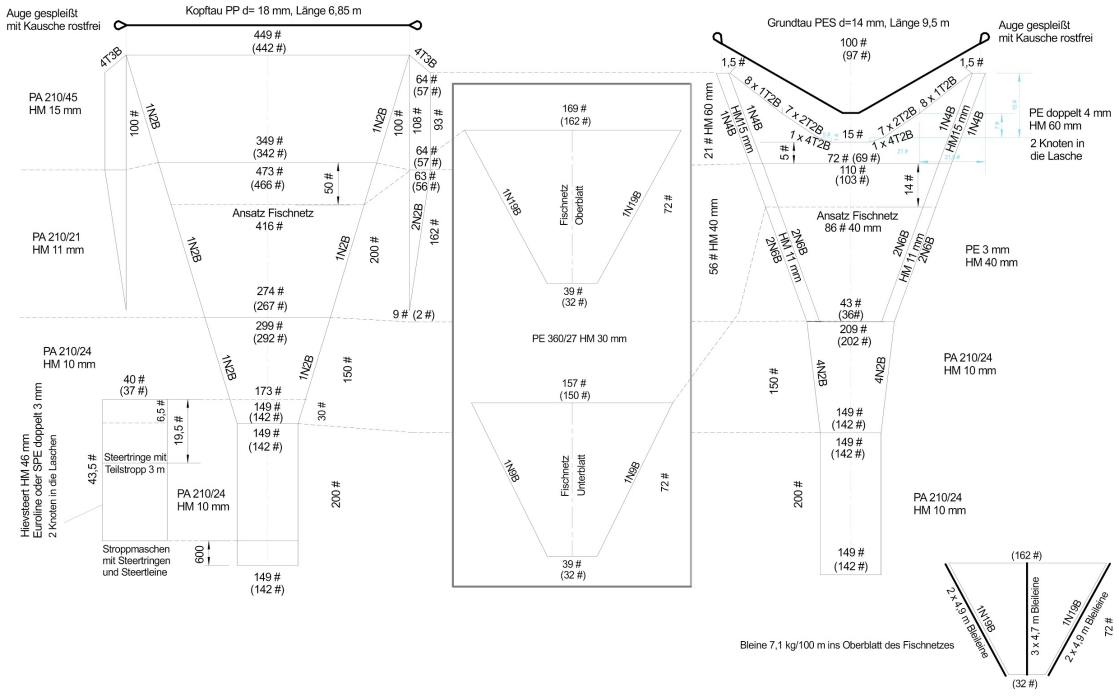

Figure 10: Ascending trawl with big meshes under panel netting

b) Changes of the ground gear (Figure 11). During the research cruises SO758 and SO767 (FRV "Solea"; 01/2019; 09/2019), a modified beam trawl with straight roller gear was tested compared with a conventional trawl (with U-shaped ground gear). The catch performance of the new straight footrope trawl was almost identical compared to the conventional trawl.

Figure 11: Straight ground gear beam trawl

Further, contacts have been established with brown shrimp skippers who will test the most promising modifications in future. This step is essential to the project and allows answering our research questions of suitability in commercial long-term use – both in terms of handling and in terms of catchability.

So far, testing of the following options is about to commence within the next months:

- Straight ground gear
- Axial offset roller ground gear
- Sieve mat as an alternative to the sieve net
- Double codend trawl to minimize the diameter of the codend
- Novel design for floatation distribution/combination of floatation and abrasion protection
- Modified sieve net

2.3.3.4 Project: STELLA

Project Full Title: Development of alternative management approaches and fishing techniques to minimize conflicts between conservation objectives and gillnet fisheries

Project Timeframe: 01/2017 – 01/2020

Institution(s): Thünen Institute of Baltic Sea Fisheries

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Link(s): **www.thuenen.de/en/of/projects/fisheries-environment-baltic-sea/gill-net-fisheries-development-of-alternative-management-approaches-stella/**

Summary:

Gillnets are one of the most common fishing methods worldwide. Along the German Baltic Sea coastline, local gillnet fisheries provide a source of income for a number of families, form a part of the cultural heritage and play a major role in the touristic attraction of the coastal region. Fishing takes place within and outside the specially protected areas, which make up around 44% of the German EEZ in the Baltic Sea. Large flocks of migratory birds pass through every season and rest within these areas. Furthermore, there is a small population of harbour porpoise in the Western Baltic. While gillnet fishing is a highly size selective fishing method, unwanted bycatch includes higher trophic species like harbour porpoises and seabirds. Data on the extent of the problem is rare since gillnet fishing is usually carried out on small vessels (often less than 12m in length) and fishermen are only obligated to deliver a monthly catch report on these vessels without any indication of bycatches.

In STELLA we combine a total of four working packages to tackle the bycatch problem from all angles and find a solution that is effective, sustainable and will find acceptance among fishermen. The project comprises the following: 1) estimating fishing effort of the local gillnet fisheries and identifying behavior patterns of different fisherman groups. 2) development of gillnet modifications to minimize bycatch of marine mammals and seabirds 3) development of alternative fishing gears 4) analyse motives of fishermen and identify incentives that may lead to enhanced acceptance of mitigation methods.

STELLA - Work package 2: Gillnet modification to reduce bycatch of marine mammals and seabirds

Previous attempts to reduce bycatch of porpoises include trials to raise the acoustic reflectivity of gillnets. Most of these studies use a trial-and-error approach and lack to address the problem in a systematic way. Furthermore, it is hypothesized that porpoises are able to detect gillnets or parts of them, but fail to recognize them as an obstacle, possibly due to masking of the netting by the highly visible floatline. The ideal object to be hung in the net should be very small, have a reflectivity similar to the floatline and be hung at distances small enough that the porpoise perceives the net and objects as an impenetrable pattern. In a systematic study, we simulated the acoustic reflectivity of a variety of objects in different shapes, sizes and bulk characteristics (e.g. Young's Modulus, density) and experimentally verified the simulations in a water tank. First simulation results indicate that commercially available acrylic glass spheres of less than 10mm diameter exhibit promising characteristics with up to -42 dB target strength at 130 kHz (the frequency used by harbour porpoise). Echograms taken with the sonar of FRV "Clupea" revealed

that the net with spheres is highly visible at 120 kHz compared to a standard gillnet (Figure 13). At 38 kHz both modified and standard gillnet were not visible.

Figure 12: Gillnet with Acrylic-pearl (diameter: 8mm)

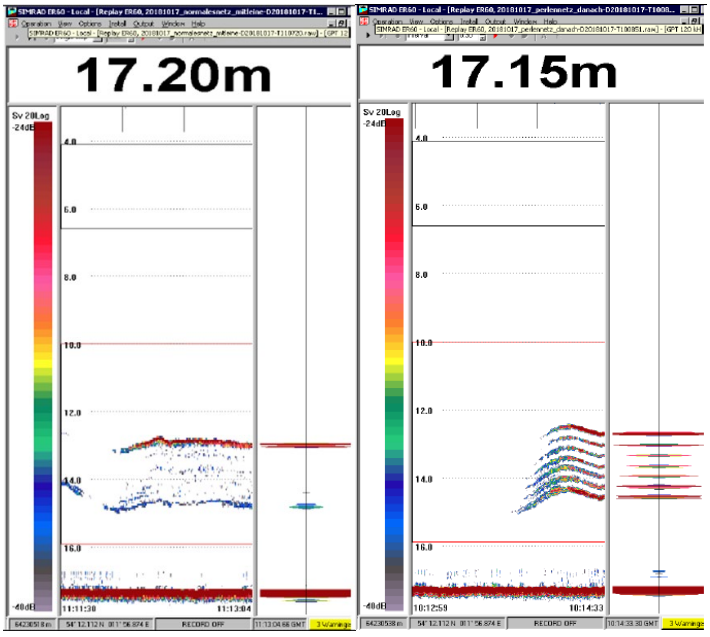

Figure 13: Echograms taken with the sonar (SIMRAD EK60, 120kHz) of FRV "Clupea": Left: stand-ard gillnet without pearls; Right: modified gillnet with pearls

Building on these qualitative trials, the target strength/scattering volume of different gillnets was measured in a controlled environment at the submarine hangar provided by the German Navy. Using an EK80 (38, 70, and 120 kHz) broadband echosounder, we determined the target strength/scattering volume of six different types of nets at different angles (0°, 20°, 45°, Figure 14):

1) standard cod gillnet (110 mm mesh size, nylon)
2) cod gillnet with spheres at 20 cm distance
3) cod gillnet with spheres at 40 cm distance
4) cod gillnet with spheres at 60 cm distance
5) commercial turbot net (400 mm mesh size, natural fibre)
6) turbot net with spheres (35 cm horizontal, 37 cm vertical)

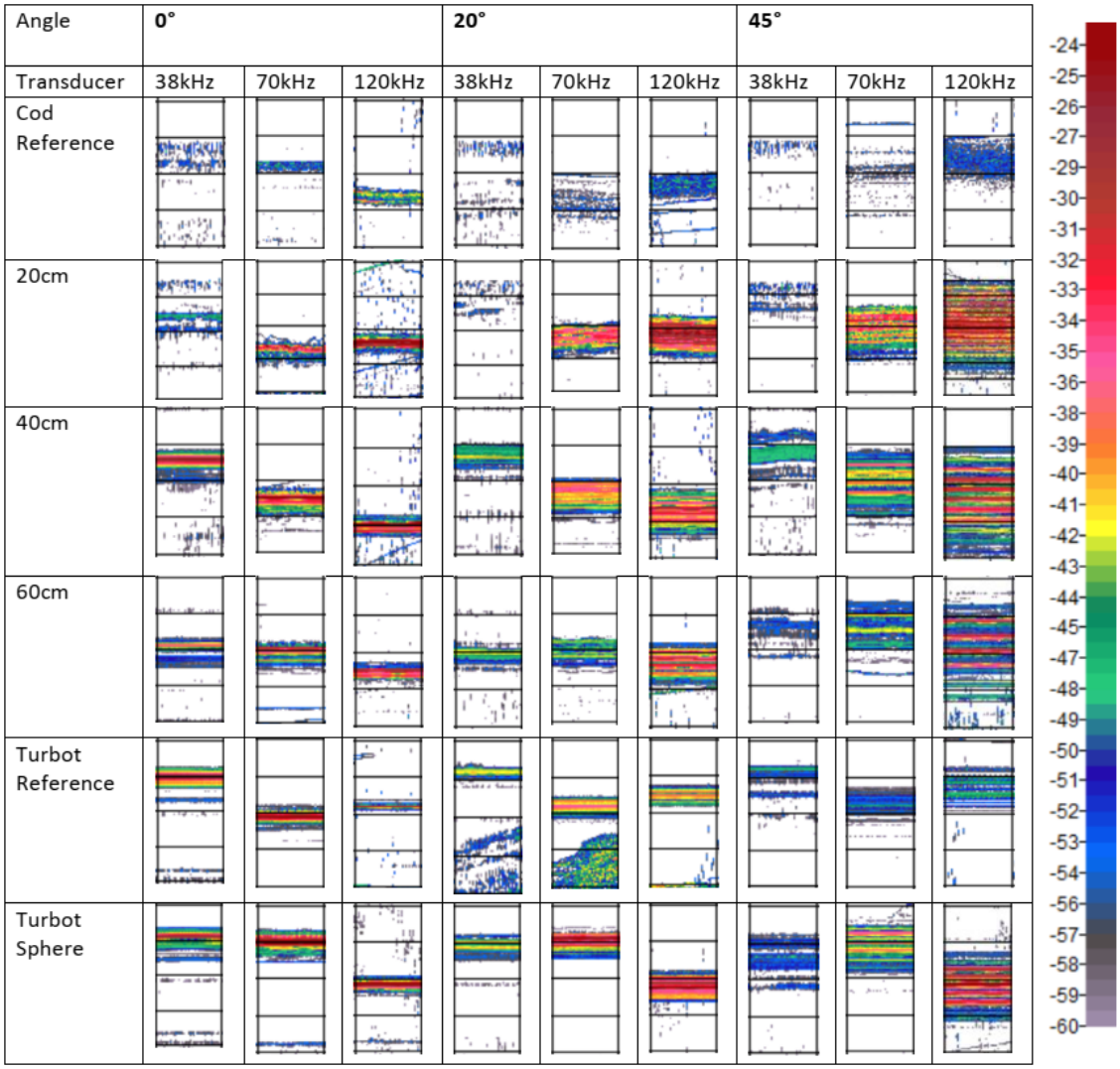

Figure 14: Volume backscattering strength (Sv) of different types of gillnets from three different angles of approach. At 120 kHz the pearls are highly visible. The gillnet becomes more and more "invisible" with an increasing angle of approach.

A field experiment carried out in Fyns Hoved (Denmark) between end of July 2018 and beginning of September 2018 was supposed to determine the reaction of porpoises to the modified net. Due to weather conditions, as well as unusual behavior of the observed animals, the experiment needs to be repeated. The rather laborious and time-consuming logistics to organize and carry out such an experiment (in 2018, 7 people were continuously observing porpoises for 6 weeks full-time) did not allow us to repeat the experiment in 2019, since another, similarly time-intense trial was carried out (see below). The trial has now been postponed to 2021.

In order to get a first indication of the efficacy of spheres to reduce bycatch of harbour porpoises, a trial was carried out in the Turkish turbot fishery. A standard turbot net was equipped with spheres at 35 to 37 cm distance and compared to a non-modified net. Each net was 2000 m long. In the 10 hauls, a total of 7 harbour porpoises were caught (5 in the standard net, 2 in the "pearl net").

Remark to international colleagues:

- We have modelled the acoustic properties of different objects for a broad range of frequencies to cover also echolocation frequencies of other marine mammals (paper submitted). Therefore, we will be able to recommend objects visible to other marine mammals, as well.
- We are looking for alternative places to carry out the behavioral experiment. The requirements are: high densities of harbour porpoises (if possible, they should pass daily), a high point for observation (e.g. a cliff), protected from wind and preferably shallow water, but that is not a must. If anybody knows a place that ticks some of these boxes, please let us know.

The next step is the industrialized production of "pearl net" or the development of an automated process to attach the spheres to the gillnet. There is also the possibility to use an alternative polymere if the acoustic properties are suitable. Suggestions and wild ideas are welcome.

STELLA - Work package 3: development and test of alternative fishing gears

This work package deals with different topics:

1. Fish pot entrance experiment: Several studies have shown that entrance type and funnels are a central factor for fish pot catchability. A detailed understanding of the different entrance types (e.g. funnel type) and characteristic (e.g. funnel length, netting material or net colour) is however still lacking, in part due to the inherent difficulty of testing entrance types/ entrance characteristics in the field. Also, field experiments usually only allow to measure the final fish number in the pot at hauling, long term recording of entry and exit rates per individual fish is (to date) not possible. Thus, in this study we will identify the influences of different entrance parameter on entry- and exit rates into and out of a cod pot with exchangeable entrances ("experimental pot"). The experiments were planned to be carried out in a net pen with individually marked cod and flatfish. In preliminary trials, we observed that flatfish would often lay themselves on top of funnels, changing the appearance of the funnel and interfering with registration of other fish individuals interacting with the funnel. Therefore, we did not undertake the main experiment with flatfish, only cod was used. The cods were observed using video cameras (daylight & IR sensitive for night-time observation, see chapter on IR-camera) and RFID (radio-frequency identification).

In an iterative approach, two different designs were simultaneously compared, differing in only one parameter. First, the influence of different entrance parameters will be tested (e.g. funnel present yes/no, funnel length, funnel colour).
The aim is to identify a description of an optimal cod pot entrance for the (German) Baltic Sea cod pot fishery. The experiments started in 2018 but were delayed due to technical problems. The technical problems were solved and the experiment was conducted in 2019. The manuscripts are currently being written.

2. Optimal bait identification for cod pots: The choice of the appropriate bait is another crucial factor for any kind of bait plume mediated fishery (longlining, angling, potting). While many different bait tests were undertaken for cod pot-fishery in general, rather few were performed for the Western Baltic cod stock. In addition, different bait studies have occasionally had conflicting results. Understanding of bait effect for cod pot-fishery is thus still low and an efficient and reproducible test is currently lacking. Thus, in this study, the reaction of cods in a tank to different kinds of bait will be observed to a) identify the optimal bait for cod pot fishery in the German Baltic Sea and b) investigate if this controlled approach works as a bait quick-n-clean test by outperforming in time and quality usually very time and resource-consuming field tests in pot fishing. We hope that this controlled approach will allow suppressing the non-controllable variables (temperature, cod presence/ absence, cod hunger level, current…) usually encountered in fisheries field tests. In the first trial phase, we will test different kinds of olfactory baits. In a later stage, we also want to explore visual and acoustic baits. A bait-flume choice tank, where fish can choose between different bait plumes presented simultaneously, thus indicating bait preference, has been developed and tested, some minor technical modifications are still pending.

3. Pontoon trap trial in Germany: Pontoon traps are frequently used in the Baltic (mainly Finland and Sweden). This type of trap has some advantages over traditional poundnets: a) relatively easy operation during regular catch inspections, b) protection of catch against seals, c) avoidance of seal bycatches (when seal exclusion devices are used). In 2018, a pontoon trap was tested by a German fisherman in the Greifswald Bay (Southern Baltic Sea, Figure 15 top). Aim of this initial trial was to test the usability along the shallow areas of the German Baltic coast. It was shown that the original design of the pontoon trap is not ideal for local conditions (mainly: trap too tall for shallow areas and hence too much exposed to waves).

   In 2019, a new pontoon version was developed and tested. The main change to the original design is that the catch chamber is not round anymore, but square which permits larger volume with same height (Figure 15 middle).
   Lower height reduces susceptibility to strong waves in shallow water. To reduce the height even more, the pontoon rack was height decreased and the pontoon catch chamber lowered. This has the added benefit that fish do not have to "climb up" into the catch chamber anymore, which probably reduces turnaround rates and thus increases catch rates. This new version performed well in field test 2019 and is currently being further developed (Figure 15 bottom). Additional changes will be a modified floor section so that it rises steadily from the centre to the two longer sides of the pontoon trap creating a sort of funnel ramp to ameliorate catch concentration in the middle when the catch is raised to the surface and thus improve catch collection.

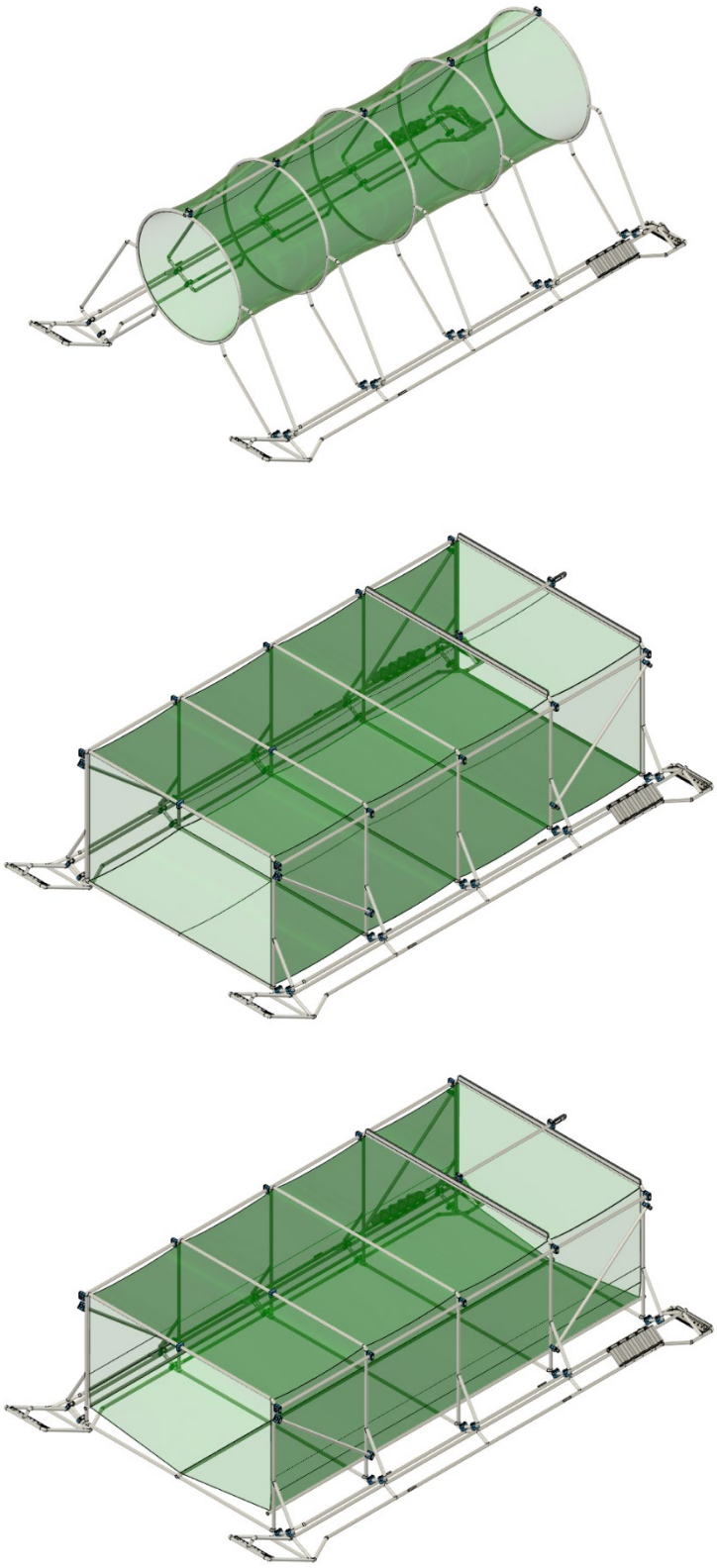

Figure 15: Different pontoon trap designs; top: original design tested in 2018; middle: re-designed for testing in 2019; bottom: pontoon trap design with modified floor section tested in 2020

2.3.3.5 Project: Open Scientific Measurement Board (OpenSMB)

Project Full Title:

Project Timeframe:

Institution(s): Thünen Institute of Baltic Sea Fisheries

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Summary:

Taken into account the way of data acquisition, fishery scientists seem to be very conservative and often stick to a simple length measurement board, paper and pen (the analogue way) - resulting in quite inefficient data sampling procedures (e.g. every single datum passes through, at least, 3 people/work steps). Although several digital data acquisition tool/electronic measuring boards for use in fishery science were developed over the last years, these are not widely used. We have figured out some major issues: a) lack of adaptability to own needs and future requirements (mostly proprietary solutions), b) restriction to one computer-platform and c) lack of modularity (use of standard hardware). In a nutshell: a system is needed, which is more "future safe".

Sustainable Ocean research (including fishing gear research), requires sustainable data acquisition technology. Open Source –solutions are obvious key elements to achieve this ambitious goal. Ideally, these solutions can

- make intensive use of user expertise and requirements,
- extent the lifetime of such tools due to independence of manufacturer-product cycles and sufficient documentation for further development, reproduction and repair,
- make efficient use of resources (available in the different institutions), when working on a joint solution, rather than spending money and effort in institution-specific solutions.

Under this premises, the 'open scientific measurement board' (openSMB) was developed, a scientific Open Source data acquisition system to be used in fisheries sciences (e.g. in Lab, at sea, at commercial vessels). The system includes a highly flexible, modular and future-proof software and hardware, which is easily adaptable to future needs in fisheries science (or even in other scientific fields, such as agriculture). Key design criteria are platform independency, use of standard industrial components, standard formats (e.g. JSON) and interfaces for data and scalable hardware. Due to the integrated SBC (single board computer) the openSMB is far more than a simple fish length measurement device with 1 mm resolution. Moreover, it can act like a complete data acquisition system, managing user defined and complex sampling schemes, interact with other devices (e.g. scales, callipers, internal and external databases, other openSMB, external display devices). The device‘s interface can be accessed remotely via Wi-Fi or Ethernet using the fully documented API in JSON-format.

2.3.3.6 Project: Infrared Fish Observation iFO

Project Full Title:

Project Timeframe:

Institution(s): Thünen Institute of Baltic Sea Fisheries

Contact person:

Andreas Hermann, andreas.hermann@thuenen.de and

Daniel Stepputtis, daniel.stepputtis@thuenen.de

Link(s):

Summary:

A sustainable ocean monitoring strategy needs sustainable technology and measurement devices because that is its primary fundament. What we derived from our long experience is: to achieve this ambitious goal, the most promising way is to follow an open source approach. On the one hand, there are plenty of good solutions published under an open source license that can be reused and adapted to our scientific needs and on the other hand, it might be useful for others to participate in the improvements.

The use of infrared video surveillance at night is very common for onshore applications and therefore hardware became efficient and cheap. Nevertheless, the observation in a dark environment is also a frequent task in fishery science. In many cases, the use of visible light is inacceptable to avoid bias of fish behaviour. Available acoustic cameras reach a high resolution at a medium range, but those are complex and expensive systems. Like humans, various fish species cannot see infrared light. So far underwater infrared video observation is not very common. One major obstacle is the relatively high attenuation compared to visible light. But with the increasing effectivity of LED technology, even very cheap CMOS cameras can cover acceptable ranges suited for many application scenarios. Our task was to observe the behaviour of cod at the entrance of different fish traps. After first tests with IR-cameras, we developed our own infrared camera and light system from standard components. It delivers underwater videos in darkness at a distance up to 1.8m. We use a consumer single computer board (Raspberry Pi) and standard industry parts. A system consists of one camera and two lights, whereas parts are below 250€ including 100m depth rated housing. It uses open source software tools running on a Linux platform. The system offers a webserver, a comfortable scheduler, a motion detection unit and can store internally more than one week continuous video data.

Additionally, we added an LTE router with internal NAS (FritzBox 7890) to be used with up to four camera systems and an external hard disk. This allows storing video data for several weeks and gains full access via VPN and LTE to the whole system. It provides remotely live videos and access to the camera‘s webserver for adjustment and setup, for instant download of data and to the camera‘s operating system for maintenance.

All fish, including cod, are commonly believed to be insensitive to IR radiation, allowing unobtrusive observation of cod in dark conditions using IR lights & cameras. This assumption has however been challenged in recent times as several fish species have been found that are indeed IR light sensitive and use it for maneuvering and foraging. Thus, to exclude any possible bias on cod observations at night using the iFO system, we, together with Barbara Koeck from the University of Glasgow and further collaborators conducted an experiment on dark conditioned cod in intermittent flow-through respirometry chambers which we exposed to sudden illumination by iFO IR lights. Absence of a significant difference in oxygen uptake before and during the IR light illumination shows that cod are indeed insensitive to IR light, the iFO system can thus be used to study cod in the dark without modifying their behavior.

2.3.3.7 Project: Flow Analysis of a Funnel-style Salmon Excluder

Project Full Title: Evaluating the role of bycatch reduction device design and fish behaviour on Pacific salmon (*Oncorhynchus* spp.) escapement rates from a pelagic trawl, see National Report USA

Project Timeframe: March 2019 – November 2019

Institution(s): University of Rostock, Germany, NOAA - Alaska Fisheries Science Center, USA

Contact person:

Karsten Breddermann, University of Rostock, karsten.breddermann@uni-rostock.de

and

Noëlle Yochum, National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center, noelle.yochum@noaa.gov

Link(s): www.lmt.uni-rostock.de

Summary:

To avoid exceeding the Chinook salmon (*Oncorhynchus tshawytscha*) bycatch limit in the North Pacific walleye pollock (*Gadus chalcogrammus*) trawl fisheries, a novel bycatch reduction device design was developed to permit escapement from the trawl before entering the codend (an 'excluder'). An observation made from previous salmon excluder trials is that the escapement rate of salmon was higher for lower towing velocities. In addition, salmonids are known to react to changes in water velocity and tend to orient toward areas of low velocity. Therefore an excluder was designed with the aim of facilitating escapement and attracting salmon to the escape area by generating low flow velocity regions. The flow field in and around the excluder design was analysed using 'Reynolds averaged Navier-Stokes' (RANS) computational fluid dynamics methods. A porous medium approach was used to represent the netting in order to simplify flow simulations, and the netting was assumed to be rigid. Based on the simulation results, configurations for a 1:2 scale excluder model were selected for testing in a flume tank (Figure 16). Computational fluid simulations showed qualitatively good agreement with measured data collected in the flume tank. These results informed the choice of appropriate netting and configuration prior to the construction of the excluder for full scale trials.

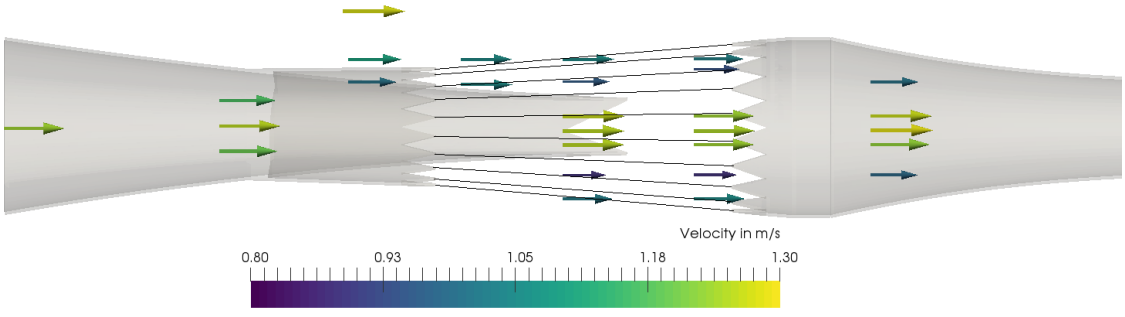


Figure 16: Side view of the excluder section. Starting points of the arrows mark the water velocity sampling posi-tions in the flume tank experiment. The water velocity data is converted to full scale using Froude scaling.

A future task should be experimental investigation of lift and drag of net panels to capture the interaction of flow and netting more accurately. In addition, the porous medium approach should be extended to allow the coupling between a fluid solver and a structural solver, where the structural solver predicts shape based on a simulated flow field. Processing the structural and the fluid solver in a loop will result in a more realistic approximation of the investigated net and flow field.

Further reading:

Breddermann, K., Stone, M., and Yochum, N. 2019. Flow analysis of a funnel-style salmon excluder. In Contributions on the theory of fishing gear and related marine systems. Proceedings of the 14th International Workshop on Methods for the Development and Evaluation of Maritime Technologies (DEMaT), 5-7 November, 2019. Izmir, Turkey, pp. 29- 42. Ed. by M. Paschen and A. Tokaç

Yochum, N., M. Stone, K. Breddermann, B. Berejikian, J. Gauvin, and D.J. Irvine. *In prep*. Evaluating the role of bycatch reduce device design and fish behaviour on Pacific salmon (*Oncorhynchus* spp.) escapement rates from a pelagic trawl.

2.3.4 Future projects and Ideas

2.3.4.1 Project: SimuNet

Project Full Title: SimuNet – net's digital twin

Estimated Project Timeframe: April 2020 – June 2023

Institution(s): University of Rostock and Thünen-Institute of Baltic Sea Fisheries

Contact person: Karsten Breddermann, University of Rostock, karsten.breddermann@uni-rostock.de

Uwe Lichtenstein, Thuenen-Institute of Baltic Sea Fisheries, uwe.lichtenstein@thuenen.de

Daniel Stepputtis, Thuenen-Institute of Baltic Sea Fisheries, daniel.stepputtis@thuenen.de

Link(s): www.lmt.uni-rostock.de/forschung/forschungsprojekte/simunet/

www.thuenen.de/en/of/fields-of-activity/research/fisheries-and-survey-technology/

Collaboration welcome?: Y

Funding secured?: Y

Summary:

In a joint effort the University of Rostock and the Thünen-Institute of Baltic Sea Fisheries will develop an open source design tool which serves to calculate the hydrodynamics and the deformation of fishing gear resulting from the flow loads. This design tool shall aid the development of innovative and ecologically sustainable fishing gear. The project will span approximately three years.

From an engineering point of view, a fishing net is a system of rigid bodies connected by a cloth-like, permeable structure that is assumed to be ideally flexible. The shape of the net is the result of the flow loads acting on the bodies and on the cloth-like structure. The flow loads, in turn, are the result of the arrangement and orientation of the bodies and the cloth-like structure in relation to each other, i.e. the result of the shape of the net. This mutual influence is called fluid-structure interaction (FSI). If questions about drag resistance, flow through or inflow to components (such as sorting grids) are to be answered, this interaction must not be neglected.

Open source software does exist either to calculate the shape of the fishing gear or to predict the flow field around and in the gear (Figure 17). Thus, on the one hand, existing software for

calculating the deformation must be modified in such a way that it uses the flow field predicted from a flow simulation for the shape calculation, and on the other hand, the geometry used for the flow simulation must be modified according to the solution of the shape calculation. Programming the necessary scripts to connect the software modules is an essential part of this project.

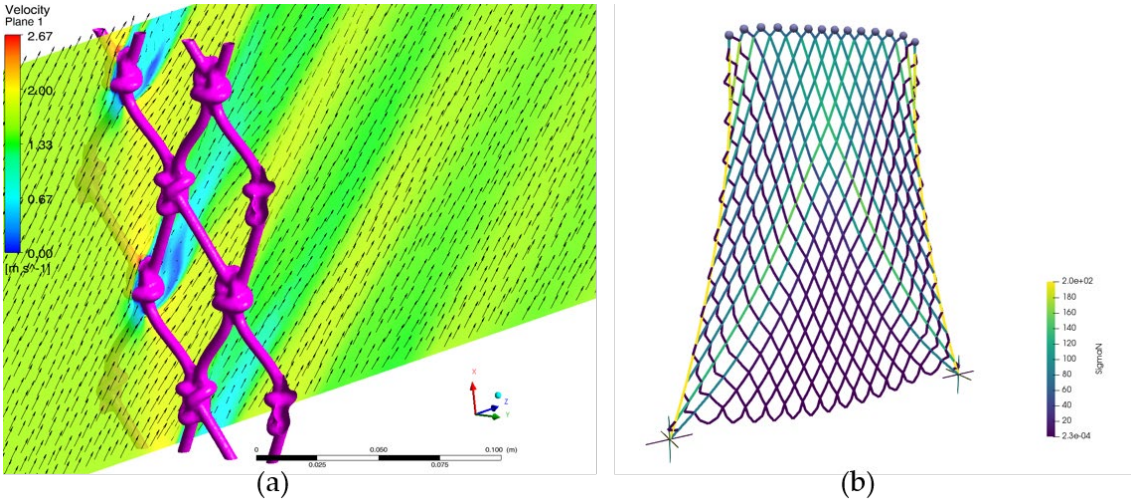


Figure 17: (a) Results of a flow simulation through and around a net panel (K. Breddermann & C. Herrmann). Arrows indicate the direction of flow and colours indicate the magnitude of velocity. (b) Load simula-tion of a net panel (C. Otto, www.ocnacademy.org). Colours indicate the tension in the bar elements.

As a first step to test the suitability and usability of the selected and adapted software for shape and flow calculation, it is intended to use it for the simulation of individual components of a small bottom trawl. The findings from the simulation results are to be confirmed in sea trials. Based on this work, first optimisation measures regarding the towing resistance of fishing gear components shall be identified and discussed with the fishery.

As the overall software (coupled software modules) develops, the entire fishing gear will be analysed and further possibilities for optimisation are proposed. A modified fishing gear, as well as the fishing gear in use, will be examined and investigated in sea trials to confirm the effect of the optimisation measures. Since the use of measurement technology in sea trials is very limited and the environmental conditions are only reproducible to a limited extent (presence of cross-currents or current components due to e.g. ship's propeller, wave movements, natural currents), trials in the flume tank are scheduled to validate the simulation software

2.4 Iceland

2.4.1 Contact person

Georg Haney, Marine and Freshwater Research Institute (MFRI), georg@mfri.is

2.4.2 Summary

- 2019 saw little change in the projects undertaken by the MFRI
- Reduced manpower has limited the ability to engage in new large-scale projects
- Fishing gear as marine litter and its implications is becoming a bigger topic

2.4.3 Projects

2.4.3.1 Project: Laser Trawling (Optitog)

Project Timeframe: 2004 – 2020

Institution(s): MFRI, Innovation Center Iceland (NMI)

Contact person: Georg Haney, georg@mfri.is

Link(s): https://www.optitog.com/

Summary:

The laser project, as it is colloquially known, is a long running project and collaboration between the MFRI and the Innovation Center Iceland. It aims to use visual stimulation to herd fish instead of bottom contacting gear. The prototype in testing is in scale almost like a possible commercial gear and consists of a towed frame with mounted lasers and an adjustable wing to fly the frame at a precise height over the seabed.

So far Haddock (*Melanogrammus aeglefinus*) and Northern Prawn (*Pandalus Borealis*) have shown positive herding behavior in relation to the laser array.

After Common shrimp (*Crangon crangon*) showed little reaction to laser light in tank trials in Belgium, similar tests were repeated in spring 2020 on Northern Prawn in Iceland. Shrimp showed limited response to green laser light but stronger flight responses to blue laser beams and strong LED lights. Design for a new prototype are being discussed.

2.4.3.2 Project: Marine Litter

Project Full Title: Fishing Gear as Marine Litter

Project Timeframe: 2018 – 2021

Institution(s): MFRI

Contact person: Georg Haney, georg@mfri.is

Summary:

In the North Atlantic fishing gear has been a major contributor to the marine waste accumulated in the past decades. The MFRI is committed to analyse the scale of the problem and to pinpoint its sources.

After establishing a classification scheme and implementing a registration protocol the MFRI started in 2019 to register all marine debris found during its regular surveys. There are three main classes: fishing gear, marine industry and waste. Within the fishing gear class gear waste can be registered by gear type or part of the gear such as trawl-net, net cuttings, longline or floatation.

Now in its second full year, the data will be continuously collected over the coming years and the distribution of waste in the Icelandic EEZ monitored and analysed.

Beyond this data collection the MFRI is participating in various efforts to understand and manage the life cycle of fishing gear to reduce the impact of marine litter.

2.4.3.3 Project: Lumpfish harvest

Project Full Title: New harvest technologies for lumpfish

Project Timeframe: 2018 – 2020

Institution(s): MFRI, University Centre of the Westfjords

Contact person: Georg Haney, georg@mfri.is

Summary:

Lumpfish *(C. lumpus)* is targeted by a fleet of small boats around Iceland for its roe. This seasonal fishery has been significant over decades as the only fisheries outside the transferrable quota system, especially benefitting fishermen in smaller remote communities. Bycatch of birds and marine mammals is significant, and the fishery has lost its MSC certification because of high bycatch levels of vulnerable species.

The aim is to develop and implement a new fishing method feasible for the fleet of small vessels currently engaged in the lumpfish fishery that eliminates bycatch of marine mammals and seabirds. The project is ongoing but currently on hold due to a lack of time, manpower and resources.

The project will also be closely aligned with other projects dealing with bycatch and discards. Notably there has been an effort to evaluate market ready technology to eliminate bycatch of small cetaceans from the Icelandic gillnet fishery. Both the Banana Pinger and the PAL porpoise alerting device have been tested with mixed results that failed to replicate the success of those devices claimed in other regions. Tests with PAL pingers with modified signals will be repeated in 2020.

2.4.3.4 Project: Fishscanning

Project Full Title: Fishscanning

Project Timeframe: 2018 – 2021

Institution(s): MFRI; Star Oddi; Hampiðjan

Contact person: Haraldur A. Einarsson, haraldur.arnar.einarsson@hafogvatn.is

Summary:

The objective of the project is to develop a lightweight and user-friendly device that provides real-time information on the catch composition. Optical technology will be used to scan the fish before it enters the cod-end and the data immediately processed. The information is then relayed to the ship by DynIce cable (or by transducer). This promises a major improvement in the analysis of catches in trawls. Today only the catch sensor gives a rough indication of catch levels.

This technology is very likely to have a significant impact on the commercial fishing fleet. The Fishscanner gives fishermen real-time information about catch composition both for species and average sizes. This in turn will help to maximize the value of catches through better organization and utilization of the fishing effort.

The project is still in the design and prototyping phase. The aim is to test a first prototype in 2020.

2.4.4 Future projects and Ideas

2.4.4.1 Project: Life Cycle of fishing gear

Project Full Title: Life cycle of fishing gear in the high north

Estimated Project Timeframe: 2020 – 2021

Institution(s): MFRI, Norway, Faroe Islands, Greenland

Contact person: Georg Haney, georg@mfri.is

Collaboration welcome?: Y

Funding secured?: Pending

Summary:

After the successful CNO gear project (Clean Nordic Oceans) that brought experts from many Nordic countries and beyond together to discuss the issue of marine litter and ghost fishing. Not as a direct successor but certainly building on the network CNO has built, a new project funded by the Nordic Council of Ministers is being suggested. It would focus exclusively on the special case of fishing communities in the high north and involve apert from Iceland also Norway, Greenland, and the Faroe Island. A special focus will be on the life cycle of gears within those communities and feasible retrieval schemes for lost gear.

2.5 Ireland

2.5.1 Contact person

Daragh Browne, Bord Iascaigh Mhara (BIM) - the Irish Seafood Develoment Agency,
daragh.browne@bim.ie

2.5.2 Summary

- Ireland continued to carry out studies related to the landing obligation and avoidance of unwanted catches in 2019.
- Three gear selectivity trials were concluded, and a fourth trial assessed the feasibility of real time monitoring of catches in a crustacean trawl fishery

2.5.3 Projects

2.5.3.1 Project: Benefits of 120 mm diamond and 100 mm T90 codends in the Celtic and Irish Seas

Project Timeframe: Nov 2018 – March 2020

Institution(s): BIM

Contact person: Dr Matthew McHugh, Matthew.McHugh@bim.ie

Link(s): https://tinyurl.com/y4kasv7y

Summary:

Scottish seiners operating in the Irish and Celtic Seas traditionally use 100 mm codends fitted with 120 mm square mesh panels (SMP), but also 120 mm codends without an SMP which helps prevent fish meshing in the SMP when hauling the seine. The latter is not included in the list of prescribed gears for the Celtic Sea under the 2019 North Western Waters Discard Plan (EU 2018/2034). This study aimed to demonstrate equivalent selectivity of the 120 mm codend with a T90 100 mm codend (one of the prescribed gears) and recommend its inclusion in the 2020 discard plan.

Key findings:

- Equivalent selectivity was demonstrated for small gadoids with less than 0.5% of cumulated haddock and whiting, and 2% of cod catches occurring below minimum conservation reference size.
- The T90 100 mm caught almost twice as much haddock and three times fewer whiting compared with the 120 mm diamond mesh codend.
- The 120 mm diamond codend was included in the list of gear options for vessels targeting whitefish species in the Celtic Sea under the 2020 North western Waters Discard Plan (EU 2019/2239)

2.5.3.2 Project: Staggering the fishing line: a key bycatch reduction option for whitefish trawlers

Project Timeframe: March 2019 – June 2019

Institution(s): BIM

Contact person: Dr Matthew McHugh, matthew.mchugh@bim.ie

Link(s): https://tinyurl.com/y2vezync

Summary:

This trial followed on from the 2017 BIM trial of a raised fishing line designed to reduce catches of quota limited or unwanted species in the commercially important Celtic Sea whitefish fishery. Fitting 1m long droppers between the fishing line and ground gear reduced catches of cod by 39%, flatfish by 57% and skates & rays by 80%, and an increase in whiting by 87%. While the results were very encouraging, post-trial testing by the vessel owner revealed some issues with gear performance in rough weather and strong tides.

In collaboration with the Centre for Sustainable Aquatic Resources, BIM organized an Industry workshop at the flume tank facility in Newfoundland to address this issue. The principal gear adjustment identified during flume tank testing consisted of altering the rigging from two single bridles to a split upper (V) bridle and lower bridle. The modified bridle arrangement was tested in the Celtic Sea on board a single-rig whitefish trawler.

Key findings:

- Substantial reductions in catches of rays, flatfish, and dogfish with more moderate reductions in catches of haddock and cod.
- Substantial reduction in catches of undersized whiting with no loss of market sized whiting
- The requirement to incorporate one meter spacing between the fishing line and ground gear was subsequently introduced (from 1st June 2020) as part of the remedial measures for cod and whiting in the Celtic Sea (EU 2020/123)

2.5.3.3 Assessment of a 90 mm T90 mesh codend, a new gear option for Celtic Sea whitefish vessels

Project Timeframe: May 2019 – July 2019

Institution(s): BIM

Contact person: Daragh Browne, daragh.browne@bim.ie

Link(s): https://tinyurl.com/y26rpexr

The 90 mm T90 codend was implemented in the Celtic Sea under the 2019 North Western Waters Discard Plan (EU 2018/2034) as a prescribed gear for vessels with catches comprising whiting or a combination of hake, monkfish and megrim. This trial aimed to test the gear against the then standard gear used to target these species, an 80 mm diamond mesh codend with 120 mm SMP, in the commercially important Celtic Sea whitefish fishery.

Key findings:

- The T90 90 mm codend is an excellent gear option for vessels targeting monkfish and megrim given a major increase in monkfish, little difference in flatfish, and substantial reductions in undersized roundfish.
- Substantial losses of above and below MCRS whiting meant that the T90 90 mm codend is not a viable gear with which to target whiting.
- A 2016 BIM trial of a T90 80 mm codend showed substantial reductions of < MCRS whiting with very small losses of whiting > MCRS.

2.5.3.4 Project: Assessment of the Notus Echo catch sensor in the Irish Nephrops fishery

Project Timeframe: October 2019

Institution(s): BIM

Contact person: Dr Matthew McHugh, matthew.mchugh@bim.ie

Link(s): https://tinyurl.com/yyk47j99

Summary:

Fish detection equipment and catch sensors help reduce fishing time and fuel consumption. However, their use has traditionally been restricted to fish rather than crustacean species which are more difficult to discern. A new catch sensor addresses this issue. Developed initially for shrimp trawl fisheries, the Notus Echo is mounted on a rigid sorting grid close to the codend. The system uses underwater acoustics and a wheel house display unit to track catches as they strike the grid and pass through the trawl. In addition to potential improvements in energy efficiency, the sensor incentivises use of the sorting grid, one of the permitted selective gear options under the landing obligation discard plan in the Celtic and Irish Seas (EC, 2018). The primary aim of this study was to calibrate device sensitivity to work for Nephrops.

Key findings:

- Preliminary field testing of the Notus Echo system provided positive results on calibrating the device to work with Nephrops.
- Optimal configuration consisted of mounting the Notus sensor on the upper part of the aluminium sorting grid with a medium sensitivity setting.
- Further field testing of the Notus system will be conducted with a modified grid with a view to maximizing uptake in gears commonly used by the Irish Fishing Industry.

2.6 Italy

2.6.1 Contact person

Antonello Sala, Italian National Research Council – antonello.sala@cnr.it

2.6.2 Summary

- Development of fishing gears and technologies for lowering the environmental impact
- Implementation of fishing practices for reducing the pressure on protected species
- Innovative tools to include socio-economic evaluations as added driver for set up fishing strategies
- Investigation of new practices under the "one healt" approach.

2.6.3 Projects

2.6.3.1 ARGOS

Project Full Title: ShARed GOvernance of Sustainable fisheries and aquaculture activities as leverage to protect marine resources in the Adriatic Sea

Project Timeframe: April 2020 – December 2022

Institution(s): Italian National Research Council

Contact person: Luca Bolognini, luca.bolognini@cnr.it

Summary:

ARGOS sets up a common framework for governance where all Institutions competent for fisheries and aquaculture in the Programme area act as a whole in the management and protection of shared biological resources, under the best scientific guidance. So the scientific Adriatic Advisory Council (AAC) is established for recommendations that are preparatory to final outputs from the Steering Committee (SC). Recommendations and final outputs come from results of multidisciplinary activities as i) Maritime Spatial.

Planning studies to deepen the overlaps in the use of marine space, ii) assessment of interactions between environmental management and socio-economic impacts, iii) standardisation of existing data on Adriatic biological resources, iv) running of bioeconomic models for stock assessments, v) implementation of pilot actions and vi) definition of a cross border network to share project results and define the best practices for training operators towards environmental sustainability and the adoption of responsible practices in fisheries and aquaculture. AAC and SC activities, as a process for governance, aim at defining common measures for the sustainable management of fisheries and aquaculture activities, in the framework of the protection of the marine Adriatic environment.

Key findings: Circular economy for marine litter – trawling for litter; Rising the environmental status of the harbours

2.6.3.2 Life DELFI

Project Full Title: Dolphin Experience: Lowering Fishing Interactions (LIFE18 NAT/IT/000942)

Project Timeframe: January 2020 – December 2024

Institution(s): Italian National Research Council

Contact person: Alessandro Lucchetti, alessandro.lucchetti@cnr.it

Summary:

Summary: Tursiops truncatus Mediterranean subpopulation is considered as vulnerable in the IUCN Red list of threatened species. The interaction of cetaceans with fisheries is a growing concern within the international scientific community. As in the Mediterranean, fish stocks are generally declining, dolphins are increasingly in conflict with different fishing activities. The unintentional catch during fishing operations, the depredation of fish from the nets and the indirect interactions with fishing activities are of great concern since they may cause negative economic consequences for the fisheries concerned. LIFE DELFI aims at reducing interactions between dolphins and fishing activities introducing mitigating devices and technical measures. The new technology will fit some simple requirements to be accepted by fishermen and to be effective: Practical at sea (do not involve major changes to the common practices, easy to use and cheap to maintain), acceptable for fishermen (economically viable), acceptable for management (achieves the management and biological targets), enforceable.

The project involves:

- Different types of pinger will be used according to different species and fishing gear. More than 300 new generation pingers with variable frequencies will be mounted on the nets of at least 100 Italian vessels to reduce fishing gears-dolphins interactions. Around 300 fishermen will be involved. A DiD (Dolphin interactive Deterrent) will be used in active and passive nets. DiD is an equipment able to keep the dolphins away from fishing nets, thanks to an efficient technique of interaction with their echolocalization system (sonar). DiD produces the ultrasounds only when it detects the presence of the dolphins inthe area, by means of its "hearing" circuitry, that is activated by the "clicks" emitted by the mammals. The advantages of this model compared with the DDDs are the reduction of the possibility that dolphins become accustomed to the signals, the increased duration of the battery charge and the reduction of the acoustic pollution. Bottom trawl, pelagic trawl, passive nets and likely purse seines will be selected for the study
- Dolphins rely extensively on visual cues, particularly when close to the prey, due to their well-developed visual system provided with a wide spectral range. This characteristic has prompted the development of visual deterrents such as flashing lamps and LED lamps to be attached to the fishing gears to discourage approaches by dolphins. But lamps can also act as a passive methods of increasing net visibility for dolphins. In the present action, around 350 new visual deterrents will be mounted on the nets of at least 30 vessels, for a total of 300 fishing days and 100 fishermen involved, to reduce fishing gears-dolphins interactions.
- To reduce interactions between dolphins and passive nets (mainly depredation of fish form the nets and the incidental catches in fishing gear) this action will stimulate the use of alternative gears. More in detail, the idea is to shift fishing from traditional passive nets, to traps, which are not dangerous for dolphins and are able to capture a high variety of demersal, benthic and pelagic species. According to the combination of target species/season/area, different types of pot will be developed and disseminated among fishermen, to discourage the use of passive nets, at least during periods at high presence of dolphins in those areas.

- The training courses for fishermen on dolphin watching practice
- The adoption of a Dolphin-friendly Code of Conduct which will be the starting point for future quality and eco-labelling
- The development of an app for smartphones will engage the large public in citizen science activities
- The creation of "Disentanglement and rescue teams" that can intervene promptly in case of dolphin capture or in all cases where it is necessary to manipulate dolphins safely and properly

Expected results are:

- Reduction of 30% in level of dolphin-fishing interactions through the improvement and spread of new bycatch reducer devices and alternative fishing methods;
- Reduction of 25% of intentional killing episodes by fishermen;
- 50% reduction of fishermen's economic losses, due to less fish spoiled or subtracted from nets, and to the damage caused by dolphins to fishing gear;
- Around 320 new generation acoustic pingers, to deter dolphins, produced and disseminated, at least 100 Italian vessels and 300 fishermen involved;
- Around 350 visual deterrents produced and disseminated, at least 30 vessels involved, replicated in Croatia (5 vessels), 100 fishermen involved;
- Around 830 alternative fishing gears (e.g. pots) produced and disseminated, at least 30 vessels involved;
- 18 training courses for dolphin watching operators, 300 fishermen trained and 50 fishermen directly involved;
- Eight information desks activated within two years of project;
- A dolphin-friendly Code of Conduct prepared and adopted by 100 fishermen;
- Nine Dolphin Rescue Teams activated;
- 1 000 people download the Dolphin WatchApp;
- Three million people reached by information materials;
- Communication campaign for local populations, A dolphin as a friend, launched, with 500 kits distributed to schools;
- Educational activities for tourists, such as sailing tours (10 events per year); and
- Networking activities with other projects, and a range of scientific publications and meetings to promote replicability in Europe.

Keywords: endangered species, environmentally responsible behaviour, fishing industry, migratory species, marine protected areas

2.6.3.3 Catching debris and microplastic

Project Full Title: Platform for technical innovation and development for fisheries operators (CISP)

Project Timeframe: January 2018 – March 2021

Institution(s): Italian National Research Council

Contact person: Emilio Notti, emilio.notti@cnr.it

Summary:

CISP is a new concept of platform for technical development in fishing operations and enhancing of competences for fishermen in Adriatic Sea (www.cisp-flag.eu). The project framework is based on a common co-creative approach, whereas fishermen are requested to actively contributed in a number of on-field activities supported by research institutes, universities, cooperatives.

The project is conceived under the general strategy of the Fishing Local Action Group (Flag) Marche Centro (www.flagmarchecentro.eu – in Italian). Primary target of this strategy is the adoption of methodical approach in technical and management strategies for a more sustainable fishery.

Some actions are intended to sustain the rising of the environmental status of the sea basins through the implementation of "environmental activities" such as the recovery of debris from the sea bottom.

Fishermen are interested in the possibility to diversify the activity at sea in particular approaching a "cleaning process" of the sea bed during the fishing closures. Such initiatives is mainly involving bottom trawl fisheries, and for the purpose of this activity a devoted fishing gear is under development, on the basis of previous experiences and on the technical knowledge coming from Tecnopesca in Vigo (https://tecnopesca.com).

The fishing net under development is set as a "reverse" series of net panels, where bottom part of the gear is ahead with respect to the belly. Moreover, the square and the belly, until the extension are made of large mesh size panels, in order to avoid the catch of fish.

The challenge with this activity is the possibility to collect debris, with particular interest on microplastic, releasing the fish, so as to be the gear suitable for being used during fishing closures.

The technical setup of the gear is also necessary as demonstrative action to suggest to decision makers a possible "rewarding approach" and to drive a circular economy approach, from the waste, through the recycling of debris and the production of new goods with added economic value.

2.7 Norway

2.7.1 Contact person

Maria Tenningen, Institute of Marine Research, maria.tenningen@hi.no

2.7.2 Summary

- Behavioural responses of mesopelagic fish to artificial light.
- Availability and catchability of wild fish assemblages around salmon aquaculture cages.
- Feasibility of mounting rigid escape mechanisms to reduce undersized specimens in crab pots.
- Catch control in blue whiting fisheries.
- Catch control, fish welfare and product quality in mackerel and herring purse seine fisheries.
- Standardisation of sampling trawls: the impact of flotation attachment method on opening height.
- Using artificial light to replace bait in fish pots.
- Trawl modification for improving size selection in the shrimp fisheries.
- Selection characteristics by altering the Nordmøre grid bar spacing in shrimp trawls.
- Different codend design reduce the bycatch of juvenile fish/ shrimp in shrimp trawls.
- Vertical separation of species inside the shrimp trawl.
- The effect of altered codend designs during Deep sea shrimp trawling.
- Quantification of gear inflicted damages on trawl-caught haddock.
- Effect of gear design on external catch damage to cod in the NEA trawl fishery
- Size selectivity with a gentle codend configuration compared to a sorting grid and a conventional codend.

2.7.3 Projects

2.7.3.1 Project: Mesopelagic fish: responses to artificial light.

Project Full Title: Effect of artificial stimuli on aggregation and avoidance behaviour in important pelagic species

Project Timeframe: January 2018 – December 2022

Institution(s): Institute of Marine Research

Contact person: Åsmund Bjordal, aasmund@hi.no

Summary:

In 2019 the first substantial landings of mesopelagic fish were made in Norway. In a trial fishery in June-July, two trawlers landed 1250 tons of Pearlside (*Maurolicus muelleri*) and 300 tons of krill (mainly *Meganyctiphanes norvegica*) after 14 effective fishing days each. Bycatch of other species was moderate – about 150 tons, mainly Blue whiting (*Micromesistius poutassou*). The catches were taken by pelagic trawl at around 200 m depth along the Western slope of the Norwegian trench.

The trial fishery demonstrated that there is still need for gear development to improve catches in this fishery. Even if catches were relatively good (max 12.3 tons/hour), underwater observations during trawling showed significant escapement of *Maurolicus muelleri* through the meshes of the top panel of the trawl. This escapement of fish should be closer studied during trawling

and methods to avoid this escapement should be investigated, e.g. the use of light to possible herding of the fish away from the trawl panel.

The behaviour of mesopelagic fish to natural light, in particular their diurnal vertical migration has been described in numerous studies over the last decades. However, little is known about the response of mesopelagic fish to artificial light.

In this project we studied mesopelagic fish' response to artificial light, by a filed study conducted in Masfjord – a fiord close to Bergen, Norway – known to have a standing stock of mesopelagic fish (*Maurolicus muelleri* and *Benthosema glaciale*). At a fiord depth of about 480m, there were three distinct sound scattering layers (SSL) of mesopelagic fish (and other organisms) at about 100-. 200- and 300m depth (SSL1, SSL2 and SSL3).

The observations were done from the 25m research vessel "Hans Brattstrøm" using a submersible rig equipped with wide band acoustic transceivers (WBAT), GoPro camera and different LED light sources. Lights used were infrared, red, blue, green or white light. The position of the rig and the overall response of the different SSL to the rig was recorded by the vessel's echosounder (Simrad EK60), in addition to the WBAT on the rig. Environmental condition, (oxygen, temperature and salinity) as well as current (ADCP) condition were monitored throughout the water column. A few biological samples were taken from the two upper sound scattering layers (SSL1 and SSL2) using a MIC-sampler.

As the rig was placed in a sound scattering layer or lowered trough a layer, the following responses were observed:

- No or little response to the rig without lights and with infrared and red lights.
- No attraction to light was observed.
- Horizontal avoidance was observed when placing a strong (20.000 mW/m^2) green, blue or white spotlight in SSL – disrupting the layer.
- When lowering the rig with white spread light (3.180 mW/m^2) slowly (2-3 cm/sec), the following response was observed: SSL1, primarily consisting of *Maurolicus muelleri,* showed horizontal avoidance. When the rig approached SSL2 and SSL3, primary consisting of *Benthosema glaciale,* the layers concentrated and descended at the lowering speed of the rig, keeping a constant distance from the rig of about 10m. The SSL2 was "pressed" down from about 200m to about 300m where SSL2 joined SSL3. From 300m and downwards – the fish in SSL3 joined those of SSL2 and was pressed down to the bottom (480m), while other organisms in SSL3 remained at SSL3-depth, probably because of no response to light or no capability of avoidance.
- When the rig was lifted from the bottom, "pressing up" of the layers was not observed – rather a horizontal avoidance response.

These studies should be regarded as introductory regarding behavioural responses of mesopelagic fish to artificial light. The present indications of a different beahvioural response between *Maurolicus muelleri* and *Benthosema glaciale* to artificial light, should be further studied as it can aid in selective fishing of either of the two species.

2.7.3.2 Project: Development of fisheries in the vicinity of salmon aquaculture farms

Project Full Title: Development of fisheries in the vicinity of salmon aquaculture farms

Project Timeframe: April 2019 – April 2021

Institution(s): Institute of Marine Research, NOFIMA, Møreforskning, Segel

Contact person: Odd-Børre Humborstad, oddb@hi.no, Anne Christine Utne Palm, annecu@hi.no; Svein Løkkeborg, sveinl@hi.no, Sten Siikavuopio, Sten.Siikavuopio@Nofima.no, Ingebrigt Bjørkevoll, ingebrigt.bjorkevoll@moreforsk.no , Paul Jacob Helgesen, paul.jacob@segel.no**Link(s):** www.gearwebsite.org

Summary:

The project aims at describing availability and catchability of wild fish assemblages around salmon aquaculture cages at three different sites along the Norwegian coast though one year. Fish pots will be used as sampling gear and quality assessment of target species saithe (*Pollachius virens*) will be conducted both inside and outside the 100 m fishery exclusion zone. The results from these trials will be compared with site description of salmon biomass inside the pens and the feeding regime to get a better understanding of temporal and geographical variation in fish aggregation. Risk assessment for fishing operations will be performed. New methods for aggregating and catching wild fish assemblages around fish-farms will be tested. Monitoring of fish availability started in late autumn 2019. Artificial light as attractor inside pots were tested but with inconclusive results due to low catches in 2019, new experiments are being planned for 2020. Artificial light and feeding (using salmon pellet feed) where tested to attract saithe away from the aquaculture cages outside the fishery protection zone. Huge schools of saithe were successfully attracted to the light and feed at distances up to 400 meters away from the cages. These results open for new capture methods of wild fish assemblages around aquaculture cages.

2.7.3.3 Project: Snowcrab fishing gear technology

Project Full Title: Snowcrab fishing gear technology

Project Timeframe: January 2017-

Institution(s): Institute of Marine Research

Contact person: Odd-Børre Humborstad, oddb@hi.no, Svein Løkkeborg, sveinl@hi.no, Terje Jørgensen, terje.joergensen@hi.no

Summary:

Experiments were conducted in the Barents Sea in march 2019 to evaluate the feasibility of mounting rigid escape mechanisms to reduce undersized specimens in crab pots while maintaining commercial size catch rates; evaluate the catch performance of six different pot types to improve efficiency; develop a nonselective pot for stock assessment purposes; test commercially available artificial bait as an alternative to expensive natural bait; test prototype "fishing gear finders" to be used on fishing grounds affected by fluctuating drift ice and to evaluate the feasibility of mounting biodegradable twines to disable pots that are lost. Results were inconclusive with regards to both selectivity and efficiency, as measures improving selectivity reduced CPUE of crab above MLS, while measures increasing CPUE of crab above MLS also increased CPUE below MLS. None of the baits tested produced any commercially interesting catch rates. Due to the long fishing season of approximately nine months, usage of standard biodegradable twine requires multiple replacements and a too high workload when each vessel may operate 12000 pots. New cassette solutions with biodegradable panels allowing for quicker replacement are

suggested as an alternative. New prototypes of fishing gear finders are produced and will be tested summer 2020 as well as new trials on efficiency and selectivity.

2.7.3.4 Project: Catch control in the blue whiting fisheries

Project Full Title: Catch control in the commercial fishery for blue whiting

Project Timeframe: January 2019 – December 2021

Institution(s): IMR, Norway

Contact person: Ólafur Ingólfsson, olafur@hi.no

Summary:

The commercial pelagic trawl fishery for blue whiting (*Micromesistius poutassou)* in the northeast Atlantic Ocean west of Ireland is challenged by difficulty controlling catch quantities, with catches sometimes exceeding 1000 tons in a single haul. This leads to problems of safety, occasional bursting of codends and challenges due to the vessels fish holding capacity. A series of depth loggers were mounted on five trawls and codends of voluntary vessels. This was done to record trawl geometry and ascent during heaving. Project participants from IMR, The Directorate of Fisheries and the Fisheries and Aquaculture Research Fund (FHF) participated on three fishing trips, observing the fisheries, testing a prototype of a catch limitation device and performing video observations.

Animations of the trawls were made, mainly to assess the ascent of the codend.

The catches ranged from less than 100 to about 900 tonnes, fishing at depths from 400 to 800 m. When hauling, the codend has positive buoyancy and the speed starts to accelerate at about 200–250 m depth. The average speed increases from ~0.5 ms^{-1} at 200 m depth to ~2.5 ms^{-1} the last 50 m depth to surface. Maximum speed of 2 - 7 ms^{-1} is obtained when the codend reaches the surface, depending on catch size, but is independent of fishing depth and vessel. At about 100–150 m depth the codend position changed from being horizontal to being approximately vertical in the water.

The video observations show fish flowing into the codend during towing. The towing speed seems to be well above the swimming capability of the fish, and no fish were observed to attempt attacking the netting in front of the codend.

Based on the observations, it is considered feasible to insert a section with very large meshes to release residual catch when the codend is full, without losing catches during fishing. A survey was planned in March 2020 to test three versions of catch limitation devices and conduct further investigations on geometry. If successful, the escape-survival potential for the released fish needs to be assessed. In addition, a release mechanism for disconnecting the codend from the fish pump is being designed and initial testings were planned. The survey has been postponed until 2021.

2.7.3.5 Project: Catch Control in purse seine fisheries

Project Full Title: Catch control in purse seine fisheries for small pelagic species

Project Timeframe: March 2017 – March 2021

Institution(s): Institute of Marine Research, Sintef and Nofima

Contact person: Maria Tenningen, maria.tenningen@hi.no and Mike Breen, Michael.breen@imr.no

Link(s): www.sintef.no/fangstkontroll

Summary:
The overall aim of the project is to improve catch control in purse seine fishing by developing instruments and analytical methods that provide a better basis for decisions during the catching process.

WP3 - Acoustic catch monitoring

The aim of the work package is to develop improved acoustic catch and gear monitoring tools and methods during purse seining and to improve the understanding of school behavior during capture. Fishery sonars are used to study mackerel, herring and capelin reactions to capture by purse seine. We have measured swimming direction and speed, fish density and school organization. In cooperation with commercial companies we are working with testing acoustic purse seine sensors for monitoring the catch and gear (Kongsberg maritime AS) and monitoring the floatline using Bluetooth technology (FossTech as). Further experiments will be carried out on board commercial mackerel and herring purse seiners in autumn.

WP4 – Catch Monitoring: characteristics and behaviour at the individual level.

WP4 aims to develop methods to monitor fish characteristics and behaviour, as well the environmental conditions, inside the purse seine net. The goal is to maximize the amount of information available to fishers, enabling enable them to make informed decisions about whether to release an unwanted catch, before it becomes fatally crowded.

To monitor and characterize the catch (with respect to species composition, individual size distribution and behaviour), as well as describe environmental conditions in the net (i.e. temperature and dissolved oxygen concentrations), HI has now developed a suite of catch monitoring platforms (CMPs) that can operate at all later stages of the capture process: in net during haul; during pumping; and in the receiving refrigerated seawater tank (RSW) tank. This uses various combinations of both fixed-aspect (GoPro) and omnidirectional (Nikon 360°) cameras and a Rinko III oxygen, temperature and depth sensor; in protective housings. In addition, the project is developing a CMP with a stereo camera to characterize the size distribution in the school before it becomes to crowded to release, or "slip".

Using the CMPs we have observed how the fish become progressively crowded in the net, which drives ordered schooling behaviour to become disordered (Figure 18), and how at high crowding densities dissolved oxygen concentrations quickly decline, particular during pumping (Figure 19). In the RSW tanks, the fish experience severe cold shock and variable dissolved oxygen saturations, which eventually become hypoxic.

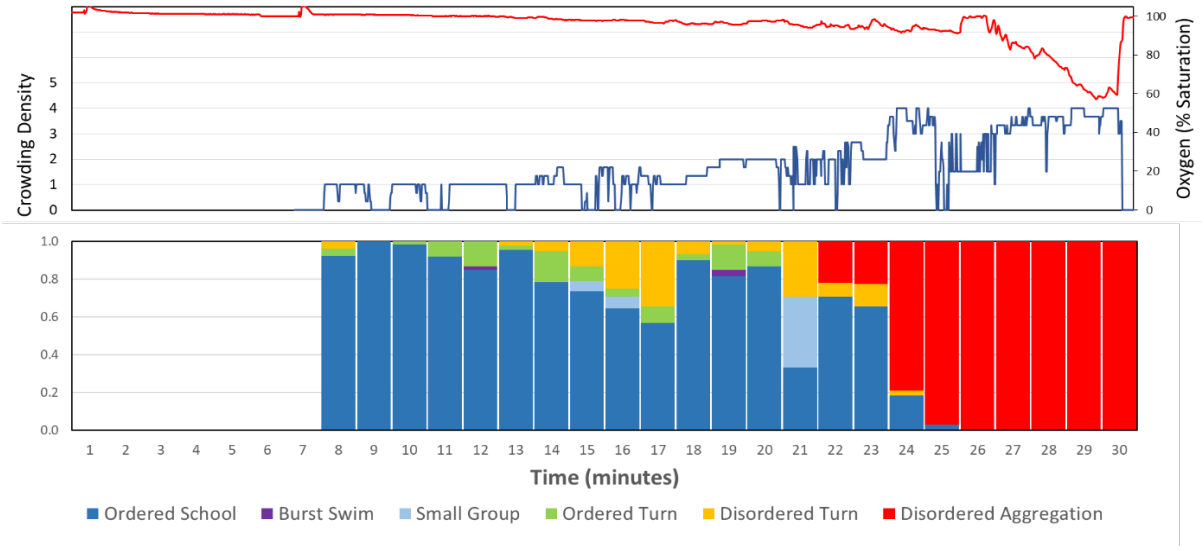
Figure 18: Top: herring in an ordered school during the early hauling phase; and, Bottom: herring becoming densely packed and disordered, close to the netting wall, late in the hauling phase.

[More examples can be seen at: https://www.imr.no/en/hi/news/2018/december/new-probe-will-increase-catch-control-in-purse-seines]

WP5 – Catch Monitoring: Catch Welfare Status Indicators

The main objective of WP5 is to "*Develop indicators of stress and potential survival in commercial purse seine fishing to help define safe limits for the release of unwanted catch*". The stress response in fish is complex and variable. It is expressed at multiple biological levels: neurologically, hormonally, physiologically and behaviourally. Moreover, it depends on what is stressing the animal, and to what degree, and responses can vary between, and even within, individual fish. So, to be confident about our interpretation of the stress responses during different phases of the capture process, we must investigate different stress indicators simultaneously.

Based on controlled experiments at the IMR facilities in Austevoll, as well as observations made during commercial fishing operations, this project has developed a suite of different stress/welfare status indicators, including: behavioural (e.g. swimming activity/tail beat frequency, state of order within school), contextual (e.g. crowding density, oxygen concentration), physiological (e.g. blood lactate, skin colour) and meat quality (e.g. fillet colour & texture). By combining different stress/welfare indicators, we can make more confident inferences about the status of the catch in terms of its stress/welfare status (e.g. Figure 19). This information will be beneficial for promoting both the survival of the released unwanted catch and the quality of the retained catch.



Stress/Welfare Status	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8	1.8	2.0	1.8	1.8	1.8	1.8	1.3	1.3	1.5	1.3	1.0	0.3	0.3
Crowding	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1.5	1	1	0	0
Hypoxia	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1
Behaviour	2	2	2	2	2	2	2	1.5	1.5	1.5	1.5	2	1.5	1.5	1.5	1.5	1	1	1	1	0	0	0

Figure 19: crowding density (score), oxygen concentration (% saturation) in relation to observed behaviours in a retained catch during hauling. The table below shows a hypothetical Stress/Welfare Status score for the catch, based on an average of three individual stress indicator scores: Crowding, Hypoxia and Behaviour.

For further details see: [Newsletter Dec 2019]

2.7.3.6 Project: Acoustic fish monitoring with flying drones (Focus Pelagic)

Project Full Title: Acoustic fish monitoring with flying drones (Focus pelagic)

Project Timeframe: April 2020 – March 2021

Institution(s): Institute of Marine Research and Birdview AS

Contact person: Maria Tenningen, maria.tenningen@hi.no

Summary:

IMR have in collaboration with a commercial drone company, Birdview as, developed a system where a scientific echosounder (Simrad WBT mini and ES200-7CDK transducer) is mounted under a flying drone and lowered into fish schools to provide acoustic measurements of individual fish or fish schools. The overall aim of the project lead by Birdview is to develop a system that fishermen or scientist can use to obtain information on pelagic fish schools, either to help fishermen locate fish schools and make right decisions before capture or to improve data collection in scientific surveys. The aim of the part of the project led by IMR is to test the feasibility of the system for estimating individual size of mackerel and school density and area for more reliable school biomass estimates during commercial mackerel fishing. The system has been preliminary tested onboard commercial fishing boats and some measurements of fish schools have been made. Challenges were experienced with take-off and landing when waves and strong wind, but the acoustic system and communication were working well. The experiments will be carried out in September 2020 with an improved drone design.

2.7.3.7 Project: Standardisation of sampling trawls: the impact of flotation attachment method on opening height

Project Timeframe: 2020 (Ongoing)

Institution(s): Institute of Marine Research

Contact person: Arill Engås arill.engaas@hi.no, Shale Rosen shale.rosen@hi.no, Melanie Underwood melanie.underwood@hi.no

Summary:

Beginning in 1998, the Institute of Marine Research instituted a system of sea tests of the demersal trawls used for fisheries surveys whose results go in stock assessment. All trawls are tested at the beginning of the cruise at a predefined location with flat sand/gravel seabed and trawl monitoring sensors are used to measure both average values and variation in trawl geometry. Any trawls not meeting predefined criteria for doorspread and opening height are not used in the survey. Several demersal trawls delivered in the past three years have had low, unstable, opening height and neither sea trials nor thorough measurements in a net loft uncovered the reason. Tests carried out in January-March 2000 suggest that the method used to attach flotation to the headrope may explain low and unstable opening height.

In recent years, the institute's sampling demersal trawls (GOV trawl used for the International Bottom trawl Survey, Campelen 1800 trawl used for most demersal fish surveys and Alfredo 3 trawl used for surveys of deep water species) have been rigged with a second "top line" above the headrope and floats attached to vertical lines between the headrope and top line (Figure 20, left). Previously, floats were attached directly to the headrope using a second rope with knots between each float (Figure 20, right).

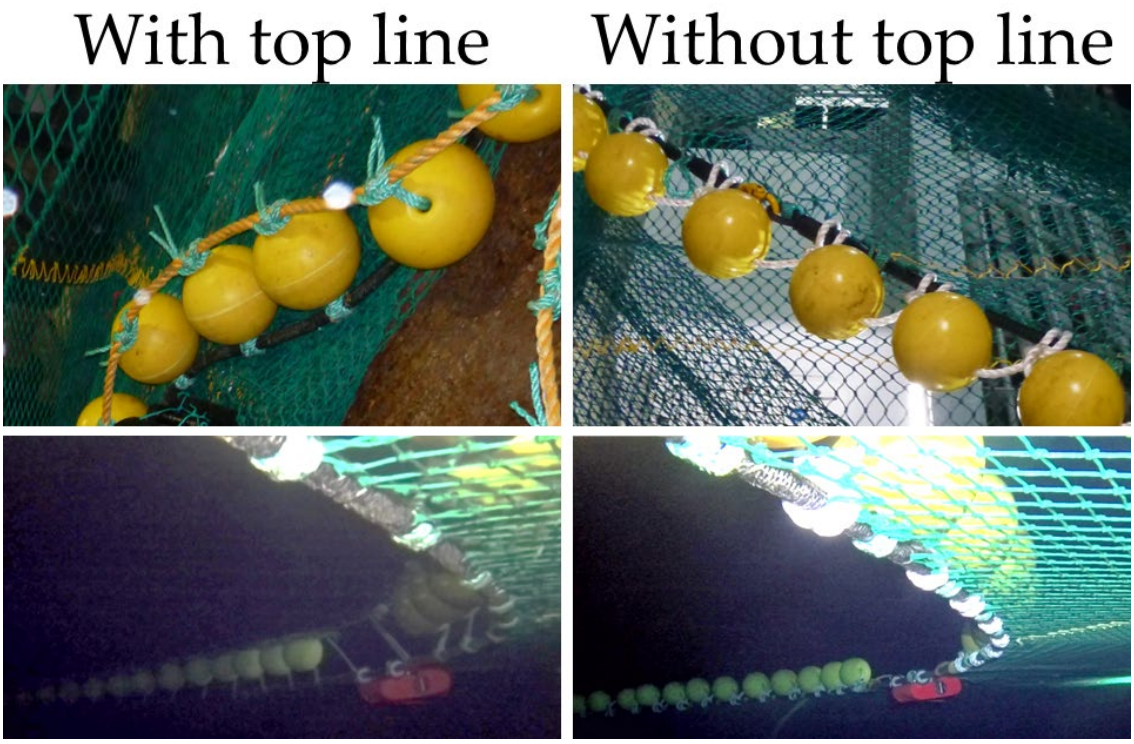


Figure 20: Methods used to attach flotation to headrope of trawl. With top line (left), without top line (right). Top photographs show detail of rigging while on deck, lower images from video taken during trawling (trawl on seabed).

Two GOV trawls, four Campelen 1800 trawls and two Alfredo 3 trawls were tested at sea, first with floats mounted using a top line and then without top line. The same trawl floats were used for both configurations. For all trawls, opening height increased by approximately 1 m when the floats were mounted without a top line (Figure 21). Simply extending the length of the top line by 3 m in order to ensure it was more slack than the headrope had no apparent effect on opening height. Analyses of stability of the trawls' geometry is ongoing, however it appears that rigging without a top line also resulted greater stability in opening height.

In light of these results, all of the Institute of Marine Research's demersal trawls have been re-rigged without a top line.

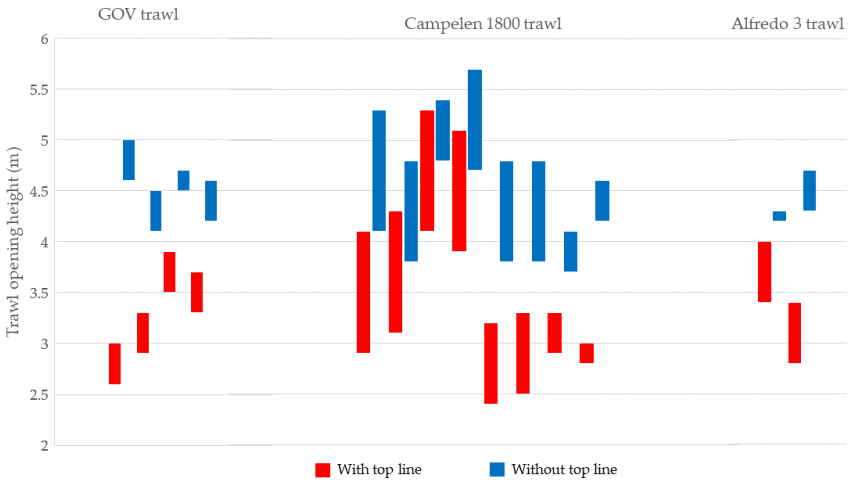


Figure 21: Results of sea trials of GOV, Campelen 1800 and Alfredo 3 trawls with floats attached using top line (red columns) and without top line (blue columns). Columns show mean values ± 1 standard deviation. Data are ordered to show paired trials, first with top line then without.

2.7.3.8 Project: Artificial Light in Fish Pots

Project Full Title: Using artificial light to replace bait in fish pots

Project Timeframe: February 2019 – February 2021

Institution(s): Institute of Marine Research, Nofima

Contact person: Svein Løkkeborg, svein.loekkeborg@hi.no

Summary:

This project is one of the work packages in a project aimed at developing a new pot design for catching cod. The objective of this part of the project is to test if using artificial light in pots can replace traditional bait types. Earlier studies have shown that artificial light in pots attracts krill, which acts as a motivating factor for cod to enter the pot. These studies have shown that pots with artificial light in combination with bait caught significantly more cod than pots with bait only. In this project we compared the catching efficiency of pots with light only with that of pots with bait only. The pots with light gave much higher catch rates than the pots with bait; three times more for cod above minimum landing size (MLS) og ten times more for cod below MLS. More fishing trials will be carried out this year.

2.7.3.9 Project: Selectivity of northern shrimp trawls

Project full title: Trawl modification for improving size selection in the shrimp fisheries

Project Timeframe: 01 2017 – 09 2020

Institution(s): Institute of Marine Research, Møreforskning, Sintef Ocean, University of Tromsø

Contact persons: Ólafur Arnar Ingólfsson, olafuri@hi.no and Terje Jørgensen, terjej@hi.no, manu.sistiaga@hi.no

Summary:

Bycth of undersized shrimp (*Pandalus borealis*) and fish juveniles are a problem in the Skagerrak and North Sea northern shrimp trawl fisheries. Prior studies in 2017 and 2018 showed that short-belly trawls can significantly improve size selection of shrimp (reduce catches of undersized shrimp while maintaining most of marketable shrimp). In 2019 we tested means to improve

codend selection by measures that provide more open meshes during fishing. The measures tested include reduction of codend circumference, four panel codends, square meshes and shortening of lastridge ropes. All measures significantly improved size selection of shrimp.
From 1 Jan 2019 the obligation to use grid in the Norwegian northern shrimp trawl fishery was extended to also include waters inside 4 n miles of the baselines. For the smaller vessels fishing here, Nephrops is and important bycatch. On request by the fisher's organizations, a series of sea trials have been made to investigate the effects on bycatch levels by using a rectangular 15 cm high Nephrops opening at the lower end of the standard Nordmøre grid. Bycatch levels were generally low, but the opening moderately increased bycatch of fish that were to large to pass through the bars of the grid and too small to be retained in the large-mesh collection bag. The trials also demonstrated that a large fraction (70-80%) of the Nephrops is lost when a grid without opening is used.

2.7.3.10 Project: Optimizing the Deep water shrimp fishery (2016-2020): National effort to solve bycatch challenges in the Norwegian shrimp fishery.

Project Full Title: Size selectivity in the Barents Sea Deep water shrimp fishery with a Nordmøre grid with 17 mm, 19 mm, and 21 mm bar spacing.

Project Timeframe: January 2019 – March 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, Pacific States Marine Fisheries Commission.
Contact person: Roger B. Larsen, Roger.Larsen@uit.no

Summary:

The Nordmøre grid with 19 mm bar spacing is compulsory in the demersal trawl fishery for deep water shrimp (*Pandalus borealis*). Even though the bycatch of fish species has been reduced by more than 95 %, the current limitations on juvenile fish still cause problem for the fishery. According to the regulations by catch number can nor exceed 3 redfish, 3 greeland halibut, 8 cod, 20 haddock, and 15 % shrimp below 16 mm carapax length. Meanwhile, it has been claimed that the largest and most valuable shrimp are sorted out with a conventional Nordmpre grid. Therefore sea trials where conducted onboard the RV "Helmer Hanssen" in the Barents Sea During the trials three different Nordmøre grids where compared; one with 17 mm bar spacing, one with 19 mm bar spacing and one with 21 mm bar spacing. The results will be published, however the data collected during this cruise has not yet been analysed.

2.7.3.11 Project: Optimizing the Deep water shrimp fishery (2016-2020).

Project Full Title: Different codend design reduce the bycatch of juvenile fish and shrimp in the Barents Sea shrimp trawl fishery.

Project Timeframe: October 2019 – October 2019

Institution(s): The Directorate of Fisheries, the Institute of Marine Research, UiT-The Arctic University of Norway

Contact persons: Ólafur Arnar Ingólfsson, olafuri@hi.no, Roger B. Larsen, Roger.Larsen@uit.no

Summary:

During October 2019 members from The Arctic University of Norway, the Institute of Marine Research and the Norwegian Directorate of Fisheries took part in a research cruise on board a commercial shrimp trawler. The aim of the research was to test new designs to improve bycatch reduction in the Northeast Atlantic deep water shrimp fishery. The selective properties of codends with shortened lastridge ropes and a design with 200 mm meshes in the aft upper panel

were studied. The 200 mm panel did not reduce the bycatch significantly. The codends with shortened lastridg ropes gave a clear reduction in bycatch of important species of fish. Nevertheless, none of the techniques reduced the bycatch below retention levels used in the Northeast Atlantic management.

2.7.3.12 Project: Optimizing the Deep water shrimp fishery (2016-2020).

Project Full Title: Can vertical separation of species inside the trawl be utilized to reduce bycatch in shrimp fisheries?

Project Timeframe: December 2019 – December 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, the Institute of Marine Research, University of Split, Pacific States Marine Fisheries Commission, Ege Universitesi, AZTI technalia.

Contact person: Roger B. Larsen, Roger.Larsen@uit.no

Summary:

Shrimp trawlers often use a Nordmøre sorting grid ahead of a small mesh codend to avoid bycatch of juvenile fish. However, small fish can pass through the grid to enter the codend and be retained. Therefore, excessive fish juvenile retention remains a problem in several shrimp trawl fisheries. In this study, we investigated the vertical distribution of shrimp and the dominant bycatch species at the position (see Figure 1.1.3.12) where the Nordmøre grid system normally is attached in the Barents Sea Deep water shrimp fishery. The purpose was to find out if there is a potential to utilize species-dependent difference in vertical distribution between shrimp and different fish species to reduce bycatch in shrimp fisheries. Our results showed that shrimp predominately follow the lower part of the trawl belly, whereas species like redfish, polar cod and American plaice preferred the mid-section in the aft of the trawl. Haddock entered predominantly the upper section of the aft belly. We predicted that if a vertical separation device was applied in front of the selectivity system used in the fishery today, i.e. a 19.0 mm Nordmøre grid combined with a 35 mm codend, a significant reduction in bycatch can be achieved with a minor loss of shrimp.

Figure 22: Left photo: A steel frame with 3 separate compartments was fixed to the shrimp trawl at the position where the Nordmøre grid system normally is attached in the Barents Sea Deep water shrimp fishery. Right photo: Various species of fish enters the compartments during towing at 3 knots in a fishing depth of 280 m.

2.7.3.13 Project: Optimizing the Deep water shrimp fishery (2016-2020).

Project Full Title: Can altered codend designs significantly improve bycatch reduction during Deep sea shrimp trawling?

Project Timeframe: December 2019 – December 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, University of Split, Pacific States Marine Fisheries Commission.

Contact person: Roger B. Larsen, Roger.Larsen@uit.no

Summary:

For almost three decades shrimps fisheries around the northern hemisphere have used the Nordmøre sorting grid ahead of a small mesh codend to avoid bycatch of juvenile fish. Small fish can pass through the grid to enter the codend and be retained. The retention of small fish, including juveniles from commercial important species, remains a problem for both the management and the practical execution of a rational fishery.

We compared the conventional two-panel diamond mesh codend with a four panel T-90 and a four panel diamond mesh codend with 20% shortened lastridge ropes. Both test-codends improved the size selectivity of the target species and improved the bycatch reduction on regulated species like cod and redfish. The design changes also improved the bycatch-reduction on typical Northeast Atlantic species like American plaice and polar cod.

2.7.3.14 Project: Bottom fish trawls and catch quality.

Project Full Title: Quantification of gear inflicted damages on trawl-caught haddock.

Project Timeframe: February 2019 – March 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, the Institute of Marine Research,

Contact person: Jesse Brinkhof, Jesse.Brinkhof@uit.no and Manu Sistiaga manu.sistiaga@hi.no

Summary:

External damages are indicators of the overall quality of fish and fish welfare. Thus, efforts to reduce external damages infringed to fish on wild-fish capture fisheries have increased substantially in the last decade. Haddock is an important commercial species widespread in the North Atlantic, but few studies related to quality have been carried out on this species. In the present study, we studied the levels of external damages on haddock captured by with a demersal trawl in the Northeast Atlantic. Further, we investigated to what extent the compulsory sorting grid and diamond mesh codend gear setup employed in this trawl fishery is responsible for the external damages observed during the capture process. We evaluated external damages (gear marks, ecchymosis, exsanguination, skin abrasion and pressure damages) on 563 haddock captured over 22 hauls. In general, the results showed that even though most external damages observed on the fish were just slight damages, catching haddock without any gear inflicted damages using demersal trawls is challenging. However, the results also showed that the severity of most damages is low and the probability to catch haddock with no external damage can be significantly increased removing the grid and changing codend design.

2.7.3.15 Project: Bottom fish trawls and catch quality.

Project Full Title: Effect of gear design on external catch damage to cod (*Gadus morhua*) in the Barents Sea demersal trawl fishery.

Project Timeframe: February 2019 – March 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, the Institute of Marine Research,

Contact person: Jesse Brinkhof, Jesse.Brinkhof@uit.no and Bent Herrmann, Bent.Herrmann@sintef.no;

Summary:

External damage incurred during the catch process is an indicator of the overall quality of fish and fish welfare. Because catch quality is difficult to improve once it has deteriorated, it is important to preserve quality during the catch process. Northeast Atlantic cod (*Gadus morhua*) is the most important species in the Barents Sea bottom trawl fishery. Bottom trawling is a non-benign fishing method, and it is therefore considered important to reduce external damage imparted to fish during capture, and subsequently improve catch quality and fish welfare. In the present study, the levels of external damage on cod captured with a new gear design were assessed in the Barents bottom trawl fishery. Furthermore, this study investigated to what extent the compulsory sorting grid and diamond mesh codend configuration employed in the fishery is responsible for the external damage incurred by cod during the capture process. In total, 750 cod captured over 25 hauls were evaluated for external catch damage (gear marks, ecchymosis, exsanguination, skin abrasion and pressure damage). The results showed that substituting the grid and codend configuration with a four-panel selective knotless section followed by a gentle codend increased the probability of cod having no catch damage by 6.00% (CI: 0.56%–11.73%). Moreover, the gentle codend led to a significant reduction in the severity of all catch damage categories, with the exception of pressure injuries, which were nearly absent for the two gear designs compared in this study.

2.7.3.16 Project: Bottom fish trawls and catch quality.

Project Full Title: Size selectivity of cod and haddock with a gentle codend configuration compared to a sorting grid and a conventional codend.

Project Timeframe: February 2019 – March 2019

Institution(s): UiT-The Arctic University of Norway, SINTEF Ocean, the Institute of Marine Research,

Contact persons: Bent Herrmann, Bent.Herrmann@sintef.no ; Jesse Brinkhof, Jesse.Brinkhof@uit.no

Summary:

Since the gentle codend configuration described in the two previous studies significantly improved the quality of the catch the next step was to estimate its potential to release undersized fish. The gentle codend configuration comprised of a large meshed four-panel section (155 mm mesh size) with shortened lastridges (30% shorter) followed by the small meshed gentle codend. The efficient release of undersized fish for the new design relies on the assumption that the majority of fish make contact with the open meshes in the gear section in front of the gentle codend, and are size selected by the meshes there. It was hypothesized that the small meshed gentle codend in the aft of the gear would cause a "bucket effect", pushing the water sideways in front of the gentle codend entry. Thus, the water would mostly flow out in the anterior section with large and open meshes increasing the possibility for undersized fish to utilize these meshes to escape as they were directed towards the meshes by the water flow. If working efficiently, such

a configuration could provide a size selection method that would not require a size selective grid, a rigid structure that complicates the gear. Avoiding the use of the grid would result in a gear configuration that is both easier to handle and less hazardous for fishermen to work with. The results from this trials have not yet been analysed.

2.8 Scotland

2.8.1 Contact person

Emma Mackenzie, Marine Scotland Science, emma.mackenzie@gov.scot

2.8.2 Summary

- SMARTFISH H2020: 2019 Fish behaviour trials – optimizing the effect of light on fish escape behaviour for whiting, cod and saithe.
- SMARTFISH H2020: 2019 Investigating the use of light to promote the selectivity of towed gears – Sea trial.
- Development of a new survey gear to replace the GOV trawl
- Fisheries Innovation (FIS): Commercial viability of fish traps
- 2020 Fish behaviour trials – optimizing the effect of light on fish escape behaviour for pollock, whiting, cod and haddock.

2.8.3 Projects

2.8.3.1 Project: H2020 SMARTFISH: Laboratory Trials

Project Full Title: Optimizing the effect of light on fish escape behaviour

Project Timeframe: Jan 2018 – Dec 2021

Institution(s): Marine Scotland Science

Contact person: Emma Mackenzie, emma.mackenzie@gov.scot

Link(s): **http://smartfishh2020.eu/**

Summary:

The overall aim of this work within the SMARTFISH H2020 project is to provide fishing skippers with technologies that will allow the modification of the fishing gear during the fishing operation. The tank trials have been designed to get an understanding of how different fish species respond to light and how this can be used to optimize escape behaviours through fishing gear.

Trials took place at Marine Scotland's Fish Behaviour Unit (FBU) observing fish reactions to a 15 m length of fibre optic cable powered by a laser pod. The laser pod was provided by Safety Net Technologies (SNTech) and was available in two colours green (peak wavelength 524 nm) and violet (peak wavelength 444 nm). To date trials for whiting *(Merlangius merlangus)*, *cod (Gadus morhua)* and saithe *(Pollachius virens)* have been completed. The 15 m fibre optic cable was positioned at the end of a tank (7m x 3m x 1.5m), the side used was alternated daily throughout the trials. Video observations were made of the fish and analysis of the footage was used to measure the mean distance of the fish at set time points throughout the trials. The mean distances were used as the unit of measure for the statistical analysis. Three batches of 8 fish were used per species. The distance (m) from the light to each of the 8 fish were recorded prior to the light being turned on to get a baseline distribution of the fish to compare to the distribution fish once the light had been turned on.

Whiting were found to have little to no response to either the green or violet colour (Figure 23) however it is thought that the ambient light level (0.14 µmol s^{-1} m^{-2}) for these trials may have been too bright therefore impacting on the level of light produced by the fibre optic cable.

The ambient light level was reduced for all further trials (0.4 µmol s^{-1} m^{-2}).

Cod had mixed results to both light colours and it appeared the fish had under lying health issues impacting the observed responses, therefore the trials were deemed invalid and need to be repeated.

Saithe trials tested three intensities of the green light. Two additional sources of light were used to achieve a suitable range of intensities to be tested which was not available with the SNTech laser pods. LED light strips were used to achieve a high intensity light level (0.55 µmol s^{-1} m^{-2}), Photosynergy LTD LED light pod powering the 15 m fibre optic cable for the medium intensity (0.34 µmol s^{-1} m^{-2}) and the SNTech pod powering the 15 m fibre optic as the low intensity (0.11 µmol s^{-1} m^{-2}). The video observations showed saithe to exhibit a strong aversive response to all three light intensities but the strength of response increased with intensity. The statistical analysis for these trials is not yet complete.

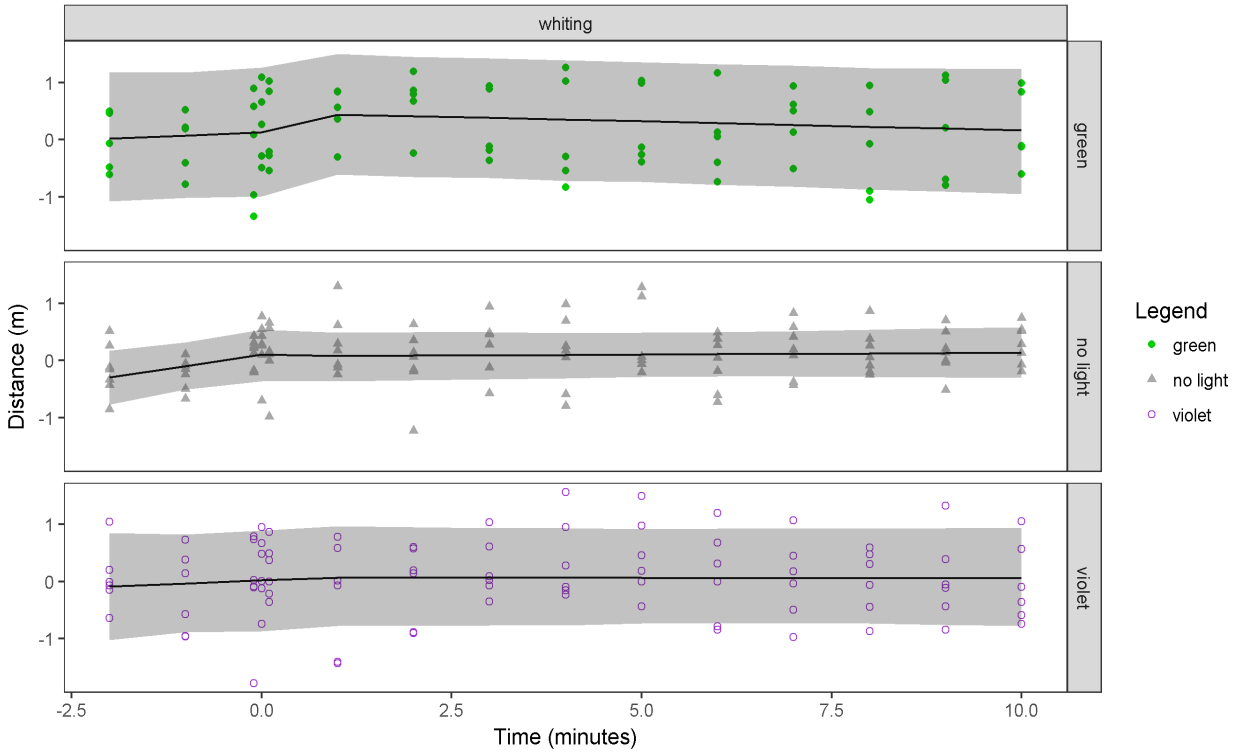


Figure 23: Whiting standardised mean distances (metres) throughout the experiment for light colours tested. The light was switched on at time 0. Points are standardised observed values, lines standardised predicted values, and grey polygons 95% confidence intervals.

2.8.3.2 Project: SMARTFISH H2020: Investigating the use of light to promote the selectivity of towed gears – March 2019 Sea Trials

Project Full Title: SMARTFISH H2020: Innovation for sustainable fisheries

Project Timeframe: January 2018 – December 2021

Institution(s): Marine Scotland Science

Contact person: Alex Edridge, Alexius.Edridge@gov.scot

Link(s): http://smartfishh2020.eu/

Summary:

Trials took place in Moray Firth in March 2019 on Alba Na Mara with a fibre optic cable attached to a rigid grid in the extension section of a trawl gear. A separator trawl fitted with a guiding panel closing the bottom chamber and with 80mm codends was used (Figure 24). The rigid plastic grid, which was made from HDPE and was 1.2 m high, 0.75 m wide and had 145 mm bar spacing (Figure 24), was placed horizontally between the top and bottom chambers. A 5mm diameter multi-strand side emitting fibre optic cable that was illuminated by a SNTech laser pod unit, which housed either a single green laser or a single violet laser and was powered by a 12V DC supply, was attached on the grid covering the surface area exposed to incoming fish.

A total of 17 hauls were completed during daylight hours (classified as being hauled before sunset) testing three lighting variables; full intensity green (6 hauls), full intensity violet (6 hauls) and no light (5 hauls). The mean curves of each species are presented in Figure 25. Significant differences were observed when comparing no light with both the green light and violet light sources for haddock, whiting, long rough dab, plaice and Norway pout. Additionally, significant differences between violet and green light were observed for whiting and plaice with higher proportions passing through the violet illuminated grid for both species. The proportions of fish from each species passing through the grid is illustrated in Figure 26. Further sea trials were scheduled for March 2020 but have been postponed due to the COVID-19 pandemic.

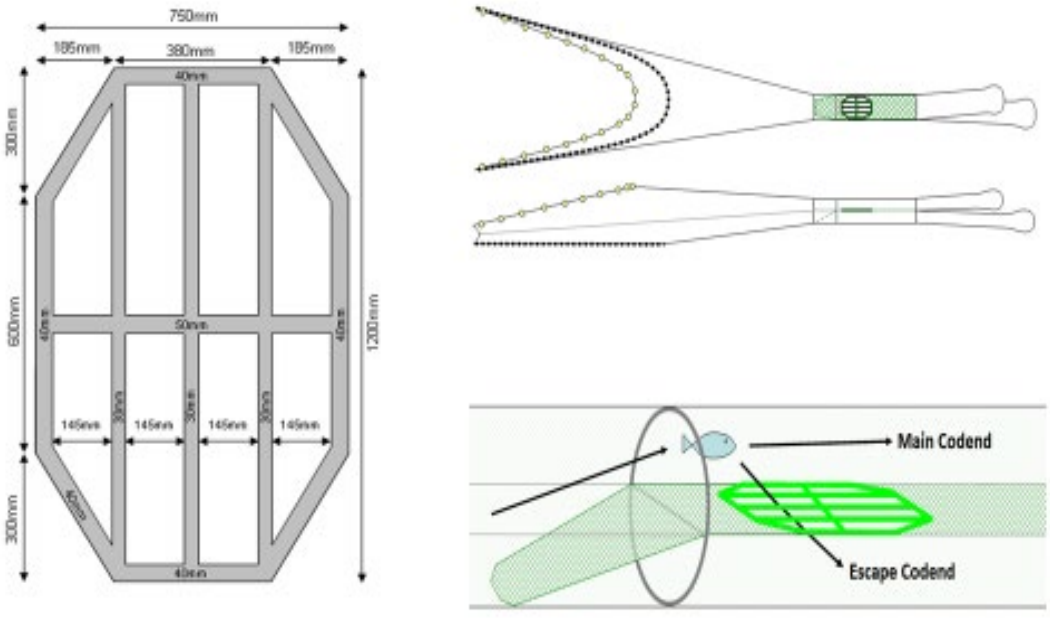


Figure 24: Grid dimensions and placement in trawl extension.

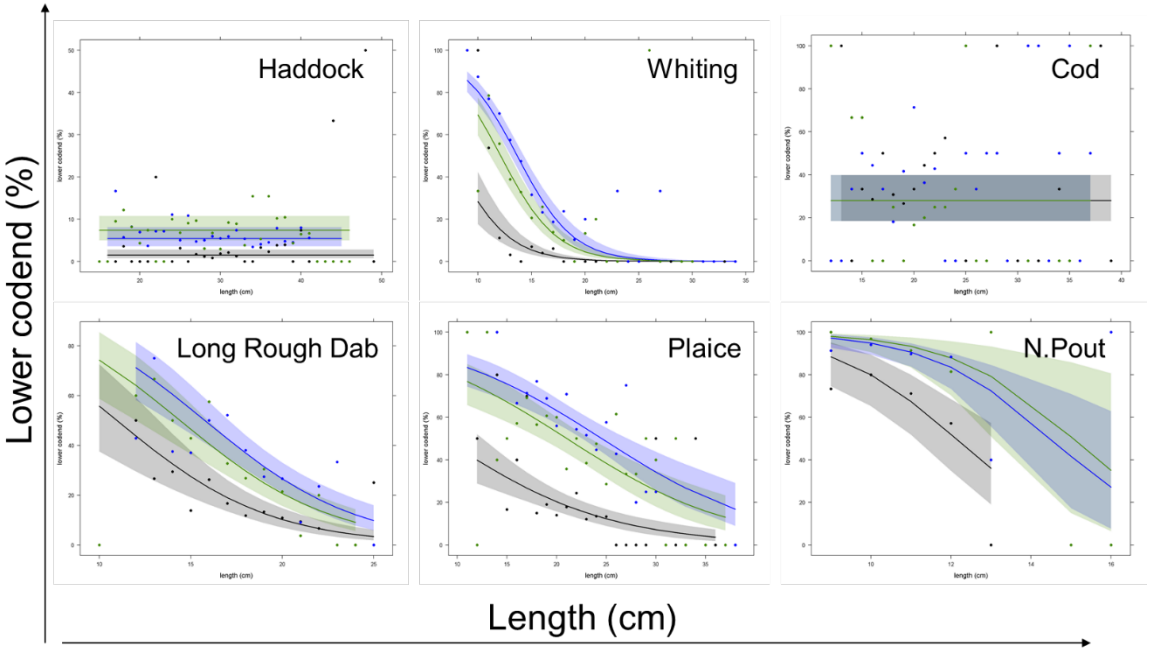


Figure 25: Mean curves for each species. Confidence intervals are represented by a shadow. (Note x-axis scale differs in each individual graph)

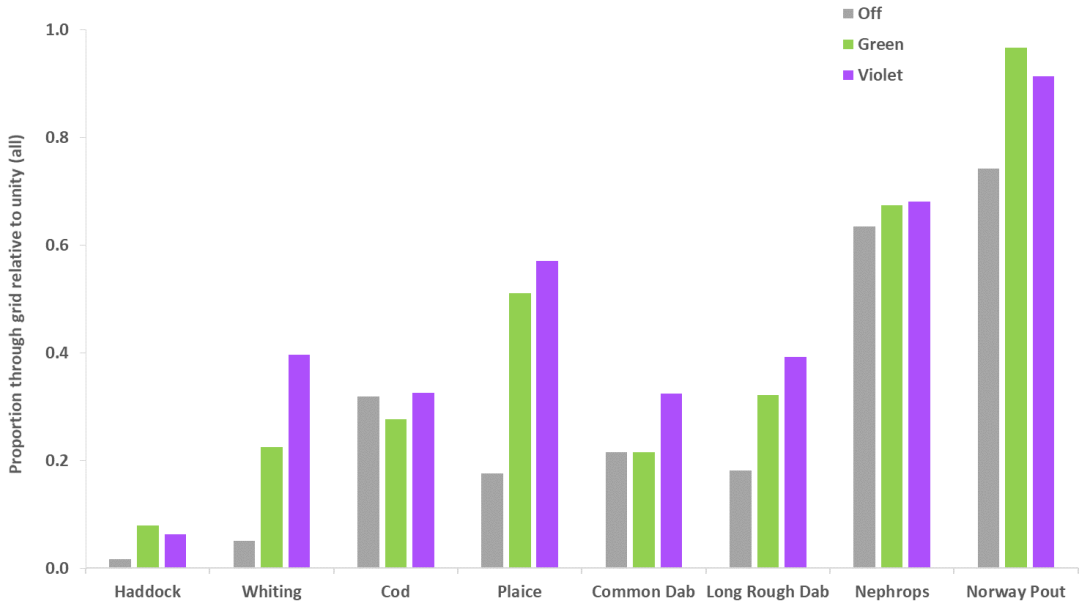


Figure 26: Proportion of fish from each species passing through the grid in each test case. Unity denotes 100%.

2.8.3.3 Project: GOV Trawl

Project Full Title: To develop a new survey gear to replace the GOV trawl

Project Timeframe: April 2018 – April 2021

Institution(s): Marine Scotland Science (Marine Laboratory) & IBTSWG

Contact person: Robert Kynoch, Robert.Kynoch@scot.gov

Link(s): None

Summary:

The IBTSWG has concluded the GOV trawl package is no longer fit for purpose and have recommended a new survey trawl package should be developed to replace the GOV. Further catch comparison and gear geometry trials were carried out using the new survey trawl (designated BT237) being developed by Marine Scotland (MS) Science as a possible replacement to the GOV trawl. The trials were undertaken for 12 days between 28 November and 9 December and looked to build on the data obtained during the 2018 trials (IBTSWG report 2018). The main objectives for these second trials were:

To undertake further catch comparison fishing tows in shallow water depth (~60m) comparing the performance of the new BT237 against the Scottish GOV with ground gear A.

To further develop a new trawl design being developed by Marine Institute, Ireland and compare the fishing performance between the two new trawl designs.

To collect gear geometry data for BT237 at various water depths starting from 30m.

The experimental trials were undertaken in the Moray Firth located off the north east of Scotland.

The haul procedure was the same throughout the trials and consisted of paired hauls of between 15 and 20 minute duration. After completion of the first paired haul the vessel steamed back to the start position (approximately 60-80 minutes from knockout to block-up) and made the second haul in the same direction but ~100m parallel to the first haul. At the start of each day and to minimize bias the order of deployment was alternated so both test and control gears were fished either first or second. Furthermore, to ensure the catches of either haul within a paired set were not influenced by towing over dawn or dusk all hauls were made in daylight. To minimize variable the same vessel towing speed (3.6kts-3.8kts) and warp depth ratios (3:1) were employed for all 3 gears. The catches were handled the same way and after each haul the total catch was sorted into individual species and then weighed. All species were then measured to the nearest 1.0 cm below. Where larger catches of a particular species were caught a sub-sample was then measured and raised to the total number caught by weight.

Sufficient catch date was collected for haddock, whiting, long rough dab, plaice and sprat for subsequent paired alternate haul analysis. Gear geometry data (headline height, door and wingend spread) for both new survey gear designs. All data is currently being analysed in the Marine Laboratory and a working document is due to be submitted to IBTSWG by mid-April 2020.

2.8.3.4 Project: FIS commercial viability of fish traps

Project Full Title: Assessing the potential for a demersal whitefish trap fishery to the West of Scotland

Project Timeframe: June 2018 – April 2020

Institution(s): Marine Scotland Science

Contact person: Emma Mackenzie, emma.mackenzie@gov.scot

Link(s): https://fiscot.org/

Summary:

This project investigates the potential for a whitefish trap fishery to the West of Scotland. At-sea deployment of newly designed gear will trial the use of baited fish traps at depth. A novel way to harvest whitefish. The research asks how this might be achieved on a commercial scale and whether the approach could be used to survey whitefish stocks.

The project work has been completed and the report is underway with submission due in May 2020.

2.8.4 Future projects and Ideas

2.8.4.1 Project: GOV trawl

Project Full Title: Further development of a new survey gear to replace the GOV trawl

Estimated Project Timeframe: November 2020

Institution(s): Marine Scotland Science (Marine Laboratory) & IBTSWG

Contact person: Robert Kynoch, Robert.Kynoch@scot.gov

Link(s): None

Collaboration welcome?: Y

Funding secured?: Y

Summary:

A further cruise is due to run on RV Scotia from 25 October to 5 November 2020. The objectives of the cruise is to further develop the new trawl package due to replace the GOV gear. The intention is for IBTSWG to hold a gear development workshop possibly September-October 2020 to refine the new survey gear package and inform objectives for the gear development cruise.

2.8.4.2 Project: SMARTFISH H2020

Project Full Title: Optimizing the effect of light on fish escape behaviour

Estimated Project Timeframe: January 2018 – December 2021

Institution(s): Marine Scotland Science

Contact person: Emma Mackenzie, emma.mackenzie@gov.scot

Link(s): www.gearwebsite.org

Collaboration welcome?: Y

Funding secured?: Y

Summary:

Continuation of the laboratory based behaviour experiments of commercially important fish species to optimize escape behaviours through fishing gear with the use of artificial light as described above.

Further experiments testing the intensity of green light are planned for pollock, haddock and cod.

2.9 Spain

2.9.1 Contact person

Mikel Basterretxea, AZTI, mbasterretxea@azti.es

2.9.2 Summary

The fishing technology area from AZTI-Tecnalia has been working last year on studies about selectivity improvements on bottom trawl fleets operating in ICES divisions 6, 8 and 9, and the impacts of a full implementation of the landing obligation in trawling fleet (increment/reduction of the workload to the crew, and to fishing cold storage space, among others). The assessment of the operational and technological adaptation of small scale fisheries to the landing obligation has been also studied, as well as possible mitigation measures of manta ray and shark bycatches onboard purse seine tuna vessels by means of the development and trial of tools and liberation protocols . Most of the projects include surveys at sea, performing and evaluating modifications of the fishing gears (gillnet designs, Square Mesh Panels (SMP) and codend configuration on trawl fishing as well as LED lights).

2.9.3 Projects

2.9.3.1 Project: MENDES2

Project Full Title: Integral approach to the minimization of unwanted catch of the Spanish trawl fleet operating in Bay of Biscay and Iberic North Western Waters

Project Timeframe: January 2019 – February 2020

Institution(s): AZTI

Contact person: Esteban Puente, epuente@azti.es

Link(s): www.azti.es

Summary:

MENDES2 is the second part of the project MENDES and is a one-year project funded by the Biodiversity Foundation (Ecological Transition Spanish Ministry) and European Maritime and Fisheries Fund (EMFF). The aim of the project is to improve the selectivity of the trawl fleet operating in North and Northwest Spanish national waters i.e. single bottom otter trawl, and pair trawl. A quantitative and qualitative analysis of the discards levels in each fleet has been performed according to the observer's database to identify case studies based on main chocke species. Workshops with skippers to review, design and select the more suitable selective devices for each fishery/species were held in different fishing ports. Sea trials in the concerned fisheries were carried out onboard commercial vessels to test the efficiency of selective devices and analyse the socio-economic impact of the implementation of such technical measures. Different selective devices were tested for the two concerned fisheries: in pair trawl a SMP set in the lower

panel of the codend was tested, while in the single bottom trawl a SMP set in the upper panel of the codend and a codend manufactured in square mesh (T45) were tested. Economic analysis was performed to assess the effect of catches pattern changes due to the selectivity devices on the viability of fishing owner enterprises.

2.9.3.2 Project: ARROD

Project Full Title: Technical and operational adequation to the Landing Obligation of the trawl fishery under a multidisciplinary approach

Project Timeframe: January 2019 – December 2020

Institution(s): AZTI

Contact person: Luis Arregi, larregi@azti.es

Link(s): www.azti.es

Summary:

ARROD is a two-year project funded by the Basque Government and European Maritime and Fisheries for Fund (EMFF). In the landing obligation context, this project is the continuation of SELAR project which during 2017 and 2018 carried out two selectivity cruises on board a commercial trawler in the ICES division 6. During these cruises, in the last 3 meters of the upper panel of the extension piece a square mesh panel was inserted. This panel was 3 meters long and covered whole upper panel in width. Moreover, the behaviour of the choke species was analysed using underwater video cameras. As a result of these trials, the tested square mesh upper panel was implemented in a new fishing regulation of 2019. In 2019 another cruise was carried out in ICES division 6 on the same commercial vessel and the objective was to deepen on the assessment of the effect of this new device implemented in the regulation. The results showed interesting escaping rates for some choke species in the fishery, like saithe, haddock or greater silver smelt. However, some escapement for target species in commercial sizes was also observed. For this year 2020, another cruise is planned under similar conditions to continue with this study.

2.9.3.3 Project: CASELEM

Project Full Title: Improvement of selectivity in trawl fisheries under the Landing Obligation of the C.F.P

Project Timeframe: January 2019 – December 2019

Institution(s): AZTI

Contact person: Luis Arregi, larregi@azti.es

Link(s): www.azti.es

Summary:

CASELEM is a two-year project, started in 2018 and it is funded by Spanish Fishing Directorate. In June 2018 the first cruise was carried out onboard the R/V Emma Bardan. In this cruise some LED lights (kindly provided by SafetyNet Technologies) placed at different trawl net locations were tested in relation to a Square Mesh Panel (SMP), as well as new configurations of the SMP. In total, five different configurations were tested by using lights with different frequencies (green and white colour lights) and the SMP set in different position on the net. These trials aimed at improving the selectivity of the trawl. In June 2019, a new cruise was carried out in the same vessel to continue testing new selectivity devices. A new configuration of the SMP was tested, this time it was placed in the lower part of the extension piece. The idea was to increase the contact of hake with the panel and therefore increase its scaping probability as we know from previous experiments that hake shows a passive behaviour in the net and moves on the lower

part of it. Another configuration tested was an experimental codend manufactured with square mesh, with the objective to assess its performance for the selected species. A total of 36 valid hauls for selectivity experiments were performed.

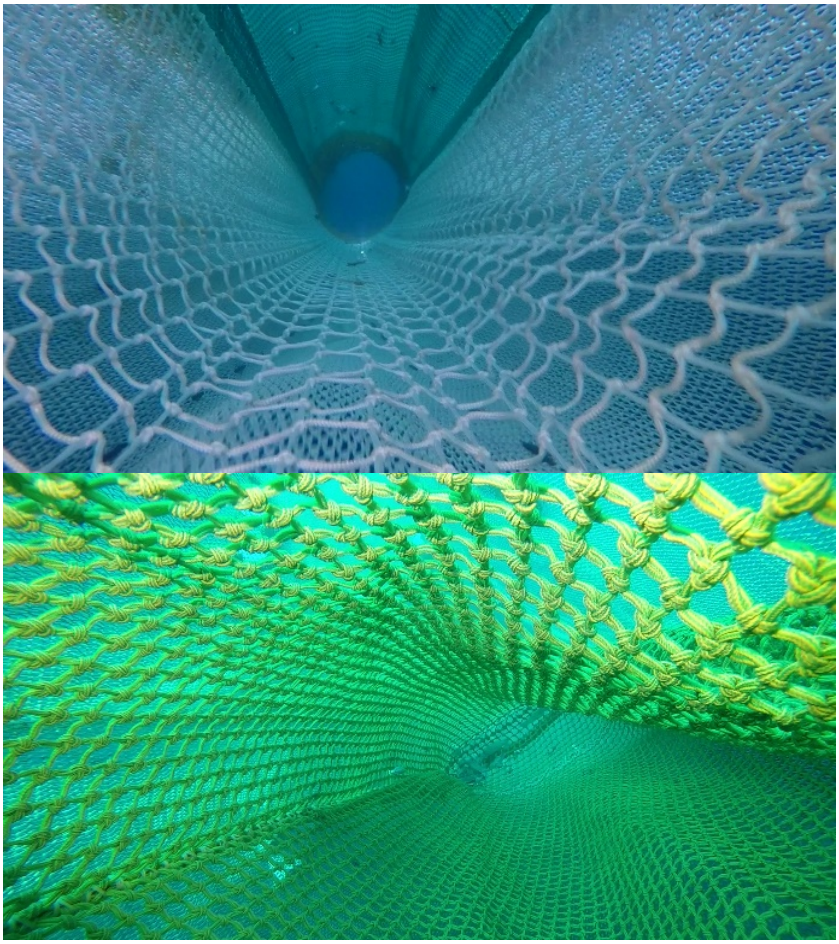


Figure 27: Square Mesh Panel in the lower part of the extension (top) and Square Mesh Codend (bottom).

2.9.3.4 Project: SOLART

Project Full Title: Technical and operational solutions for adapting the Artisanal gillnet fleet to the Landing Obligation from a multidisciplinary approach

Project Timeframe: November 2018 – October 2020

Institution(s): AZTI

Contact person: Xabier Aboitiz, xaboitiz@azti.es

Link(s): www.azti.es

Summary:

SOLART is a two-year project funded by the Basque Government and European Maritime and Fisheries for Fund (EMFF). Small scale fisheries are significantly affected by Landing Obligation (LO), particularly those using gillnets and trammel nets, where there are significant unwanted catches of mackerel and horse mackerel during some periods of the year. The most affected artisanal fishing metiers are trammel nets targeting sole, that can have high catches of unwanted mackerel in winter and early spring, as well as gillnets targeting red mullet with high catches of unwanted horse mackerel in early summer. Modified gillnets and trammel nets have been designed to try to reduce unwanted catches, which are going to be tested at sea onboard artisanal fishing vessels. Information on the catches of new designs of trammel nets and gillnets will be collected to assess the reduction of unwanted catch (mackerel and horse mackerel) as well as the amount of the wanted catch in order to perform an economic study to assess the sustainability of the technical measures suggested.

Figure 28: Top: New design gillnets and bottom: new trammel nets testing.

2.9.3.5 Project: SIBALO

Project Full Title: Simulation and evaluation of the value chain of Otter Trawlers (boat and land) before the implementation of the Landing Obligation

Project Timeframe: November 2017 – October 2019

Institution(s): AZTI

Contact person: Xabier Aboitiz, xaboitiz@azti.es

Link(s): www.azti.es

Summary:

SIBALO is a two-year project funded by the Basque Government and European Maritime and Fisheries for Fund (EMFF). The aim of the project has been to simulate the effects of a full implementation of the Landing Obligation. The initial hypothesis to be tested was that there would be a significant increase in the workload of the crew as well as several limitations for the cold storing of the unwanted catches previously discarded and retained under the new LO regulation, including impact on the fishing trip logistics. Physical condition of the crew has been monitored and measured with a motion suit and the increment in the workload analysed and compared with work conditions before LO. The management of discards at harbours (infrastructure and labour needed), market destinations for the unwanted retained catches and new processed fish products with added value had been also studied in the project.

Figure 29: Physical condition of the crew has been monitored and measured with a motion suit and the increment in the workload analysed and compared with current situation.

2.9.3.6 Project: MARINLIGHT

Project Full Title: Survey for selectivity improvement of bottom trawling fleet from Marín (Pontevedra) using lights in the net

Project Timeframe: January 2019 – December 2019

Institution(s): AZTI

Contact person: Luis Arregi, larregi@azti.es

Link(s): www.azti.es

Summary:

This is a one year project which includes a survey onboard the R/V Emma Bardan. The objective was to analyse the effect of artificial light on the selectivity of the bottom trawl net in relation to the species under Total Allowable Catch (TAC) in the Spanish fishing grounds. The Pisces lights were distributed along the float-line of the net and two different colour configurations were tested, solid green and solid blue. Catch data were statistically analysed. Underwater cameras and video recordings obtained were used to analyse the behaviour of fish in relation with the lights.

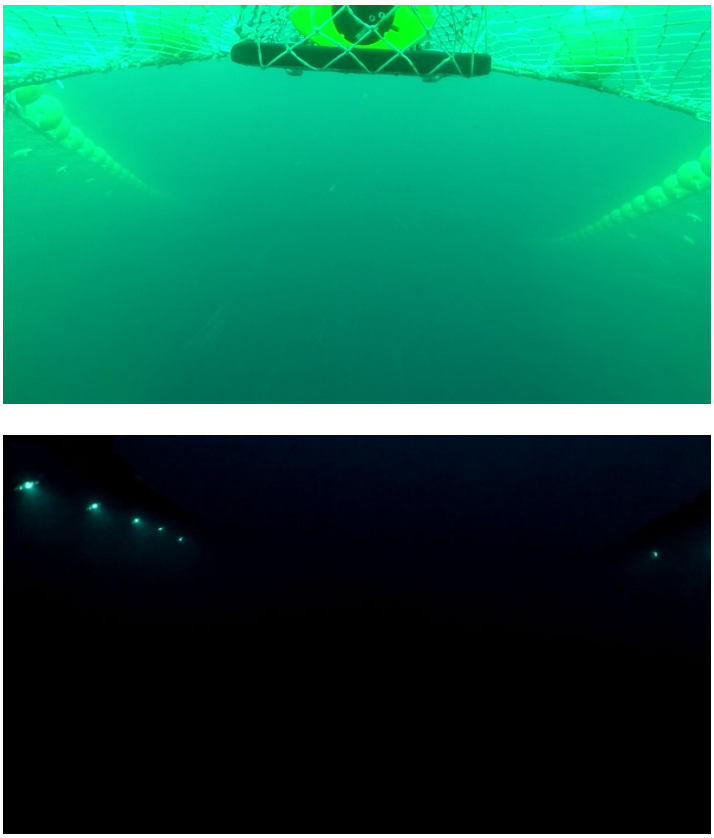


Figure 30: Lights along the mouth of the net, during the deployment (top) and once the net is towed on the seafloor (bottom).

2.9.3.7 Project: SMARTFISH

Project Full Title: Smart fisheries technologies for an efficient, compliant and environmentally friendly fishing sector (SFS-22). SMARTFISH

Project Timeframe: January 2018 – December 2021

Institution(s): AZTI

Contact person: Gorka Gabiña, ggabiña@azti.es

Link(s): www.azti.es

Summary:

SMARTFISH is a H2020 funded European project. It is involved in the Landing Obligation (LO) context, included in the new Common Fisheries Policy (CFP). The role of AZTI is to coordinate and carry out several tests on board fishing vessels to assess and verify the effectivity on the selectivity of a SmartGear device in a trawler in the Bay of Biscay and the SeinePrecog device in a purse seine vessels to be tested first in the Biscay Bay commercial fisheries, the after in Black Sea and Aegean Sea fisheries. Sea trials are planned for 2020 and 2021. SmartGear consists of a grid illuminated with LED light technology; the grid will be installed before the trawl codend. SeinePrecog consist of a sophisticated acoustic system (sound, software, filter) developed with Zunibal (private company project partner) and image system (3D underwater Utofia Camera and HD camera) to be tested on purse seine fishing; the whole system will be used to give information to the skipper before setting the net and do the seine with the aim to avoid unwanted catch in terms of species and sizes. During 2019, SmartGear tests were designed with the shipowner of the trawl-fishing company (Larrasmendi Bi S.L.); in addition the housing (hydrodynamic steel box) of the sensors, such as, sound and image cameras, was developed (3D designed and manufactured); the housing was installed on a side of the hull of the purse seine vessel, under the water; the attachment plate was welded on the hull of the vessel in order to make possible the final installation of the SeinePrecog system-prototype.

2.9.3.8 Project: HELEA

Project Full Title: Development and trial of tools and protocols of manta ray and shark liberation onboard purse seine tuna vessels

Project Timeframe: January 2018 – April 2019

Institution(s): AZTI

Contact person: Jefferson Murua, jmurua@azti.es

Link(s): www.azti.es

Summary:

HELEA is an 18-month project funded by the Basque Government. The aim of the project is to design, construct and test new shark and manta ray release equipment for large-scale tropical tuna purse seiners to maximize both crew security and bycatch species survival during release operations from deck. Several tool prototypes such as sorting grids, release ramps, holding gadgets and other implements have been constructed and tested in trials at sea during commercial fishing trips. In addition, the efficiency of hoppers as a tool to release more efficiently sharks from the top deck was checked in four tuna purse seiners using electronic monitoring system observer data. The results will be shared with the tuna fishing industry hoping that these best practice release tools for vulnerable marine species are adopted and used on a regular basis during commercial fishing operations.

2.9.3.9 ALDFG:

Project Full Title: Abandoned, lost and derelicted fishing gear (ALDFG).

Project Timeframe: September 2019 – June 2020

Institution(s): AZTI as a member of a consortium led by MRAG (Ireland)

Contact person: Martin Aranda, maranda@azti.es & Luis Arregi, larregi@azti.es

Link(s): www.azti.es

Summary:

This study is contracted by the EU agency EASME and funded by the EMFF. The study stages comprise: (1) a literature review, (2) a workshop with key stakeholders and gear technologists from which a set of recommendations have been elaborated, and (3) a validation exercise where a large number of stakeholders will be approached trough a survey online to obtain validation of the project recommendations.

The objectives of the ALDGF study are

- To conduct a review and critical analysis of the state of the art of the ALDFG problem.
- Identify existing challenges (legal, practical) to collect, redesign, reuse and/or recycle ALDFG and EOL fishing gear, best practices and available technologies, voluntary commitments and certification processes.
- Propose recommendations for effective, useful and harmonized standards on the circular design of fishing gear with a view to their reuse and facilitating recyclability.

2.10 United States of America

2.10.1 Contact person

Mike Pol, Massachusetts Division of Marine Fisheries, mike.pol@mass.gov

2.10.2 Summary

- Take reduction of marine mammals through development of alternative methods of fishing and gears was ongoing in several areas.
- A wide range of technologies, from relatively simple weighted swivels on longline hooks to high end methods, such as acoustics, computer modelling, stereo cameras, ropeless pots, and flume tank testing, are being used or developed.
- Use of lights in trawls to separate catch and bycatch is a continuing in multiple fisheries.
- Basic studies of fish behaviour, including swimming speeds at different temperatures for flatfish and movement of whelks, were underway.
- Pelagic gear types were more prominent than usually reported.
- Changing fish distributions related to climate change was studied.
- Future work on rockfish and red hake reduction in trawls is planned.

2.10.3 Projects

2.10.3.1 Project: Laboratory Observations of Channeled Whelk (WhelkCam)

Project Full Title: Developing a small whelk bycatch reduction device for channeled whelk pots in Massachusetts

Project Timeframe: November 2019 – March 2020

Institution(s): Massachusetts Division of Marine Fisheries

Contact person: Mike Pol, mike.pol@mass.gov

Summary:

We recorded movement and behaviour of a marine snail, channeled whelk (*Busycotupus canaliculatus*) as a first step to development and testing of a modification to reduce bycatch of immature individuals in a targeted fishery (Figure 31). Thirty-three individuals were held in a 2-meter diameter flow-through tank in a laboratory setting. Seven different trials were conducted to help identify possible pot modifications. Behaviour was filmed continuously during trials and later viewed at 31.25x and annotated. Trials focused on basic movement, pot entry and escape, and bait preferences (Figure 32). Whelks moved slowly but frequently, and activity levels appeared linked to water temperature. No mortalities were observed. Pots effectively kept all whelks inside, but did not appear to be very efficient. Whelk climbed sides of the tank but rarely climbed sides of a pot. Lobster appeared to be preferred over bluefish and green crab. Future directions are still under discussion.

Figure 31: Channeled whelks on the side of a tank

Figure 32: Whelk pot with bait and whelks

2.10.3.2 Project: Off-Bottom trawls (OBT)

Project Full Title: Complementary Testing of Off-Bottom trawls to Target Georges Bank Haddock

Project Timeframe: January 2017 – March 2020

Institution(s): Massachusetts Division of Marine Fisheries; Gulf of Maine Research Institute; School for Marine Science and Technology – Univ. of Massachusetts Dartmouth

Contact person: David Chosid, david.chosid@mass.gov

Summary:

We compared catch, bycatch and handling of two pelagic trawls (doors and nets completely off-bottom) against a demersal selective trawl (the Ruhle trawl) to target haddock *Melanogrammus aeglefinus* on Georges Bank, USA. This gear type has very limited use in the northeastern USA. Multiple mensuration methods were used to try to determine if pelagic trawls could be fished consistently at approx. 1 meter off-bottom. Tuning trips were conducted for the two different trawls, followed by comparative testing vs. a Ruhle trawl. At this writing, a final report was under development, but preliminary results suggested pelagic trawls may result in lower bycatch than the selective Ruhle trawl when targeting haddock. Pelagic trawls require more effort to deploy and to fish than demersal trawls, as well as more instrumentation.

2.10.3.3 Project: Revision of Existing Silver Hake Special Access Areas (Expanded-Whiting)

Project Full Title: Revision of Existing Silver Hake Special Access Areas

Project Timeframe: January 2016 – March 2020

Institution(s): Massachusetts Division of Marine Fisheries; National Marine Fisheries Service

Contact person: Mike Pol, mike.pol@mass.gov

Summary:

Possible alteration of the timing of opening of a special access area has been investigated in the summers of 2016, 2017, and again in 2019. Under an experimental fishing permit, vessels fished

for silver hake *Merluccius bilinearis* using the mandatory raised footrope trawl off Gloucester, Massachusetts with 100% observer coverage in the two weeks prior to the opening date. Observers quantified catch and bycatch in this fishery conducted with small mesh (63.5 – 76.2 mm; 2.5-3.0 inch) codends. Results from 2016 and 2017 showed excessive levels of bycatch in the early opening, primarily from small haddock. These results were not very different from the in-season bycatch rates. Results from 2019 showed a lower level of interest by fishermen and catch data have not been analysed yet.

2.10.3.4 Project: Flounder swimming

Project Full Title: Swimming speed and reaction capability of yellowtail and windowpane flounder at different temperatures

Project Timeframe: July 2017 – June 2020

Institution(s): University of Massachusetts Dartmouth, School for Marine Science and Technology

Contact person: Pingguo He, phe@umassd.edu

Summary:

This project is to measure swimming speed and reaction time of these two flounder species in relation to water temperature in an effort to understand their ability to escape from scallop dredges. Muscle contraction times of flounders are being measured at different temperatures to predict their swimming speed during different seasons. Reaction times of these species are measured by recording and analysing fish reaction to electrical stimuli. While data are still being collected, there seem to be substantial delay of reaction at lower temperatures. Longer delayed reaction and lower swimming speed can have a large negative consequence when escaping from fast-approaching fishing gear such as scallop dredges.

2.10.3.5 Project: Stereo camera for fish assessment

Project Full Title: Developing a stereo video system for non-extractive and non-impact stock abundance surveys in complex seabed habitats

Project Timeframe: January – December 2019

Institution(s): University of Massachusetts Dartmouth, School for Marine Science and Technology

Contact person: Chris Rillahan, Crillahan@umassd.edu

Summary:

A stereo camera system was developed and deployed to assess abundance of structure-oriented black seabass in Buzzards Bay, Massachusetts. The system was deployed together with fish pots in different season to document habitat-association and seasonable variation of tautog.

2.10.3.6 Project: HD camera for monitoring scallop dredge

Project Full Title: *In Situ* high-definition camera monitoring to evaluate catch efficiency and performance of a survey dredge

Project Timeframe: January – December 2019

Institution(s): University of Massachusetts Dartmouth, School for Marine Science and Technology

Contact person: Chris Rillahan, Crillahan@umassd.edu

Summary:

The project will conduct *in situ* observation and monitoring of a sea scallop survey dredge to understand and evaluate its catch efficiency and selectivity under different habitat conditions. High-definition video cameras equipped with synchronized strobe lights will be used to document size and density of scallop in front of the dredge. An inclinometer will be placed on the survey dredge to measures dredge tilt angle and bottom contact. Together with bag sampling, dredge efficiency, selectivity, saturation and other aspects of dredge performance across a range of habitat types and survey conditions (i.e. densities of scallops and debris) will be determined. Information on bycatch species will also be collected in an effort to estimate species-specific dredge efficiency estimates.

2.10.3.7 Project: Ropeless fishing

Project Full Title: Testing a ropeless fishing prototype (Figure 33) for eliminating large whale entanglements in pot fishing gear

Project Timeframe: September 2018 – September 2020

Institution(s): ACCOL (NEAq), Woods Hole Oceanographic Institution

Contact person: Tim Werner, twerner@neaq.org

Link(s): https://www.bycatch.org/news/new-award-evaluate-ropeless-fishing

Summary:

Aim: Test one or more on-call buoys secured at depth except when acoustically released for hauling (Figure 34 and Figure 35). The objective is to create a mechanically practical way to fish with pots that eliminates vertical lines from the water column, which create entanglement risk to North Atlantic right whales and other non-target species.

Results/Status: All deployments to date have had 100% successful retrieval of a bottom-attached flotation rope spool. Testing will continue throughout 2020.

Future: Parallel projects involve the development of systems that will allow all fishermen to visualize the location of fishing gear on the seafloor in the absence of surface buoys. This is important for avoiding gear conflicts between fishermen, and to assist regulators in monitoring gear that lacks surface identification. Economic and regulatory questions similarly must be addressed to make this system practical, and this project will reach out to expertise for developing options that can meet these needs and concerns.

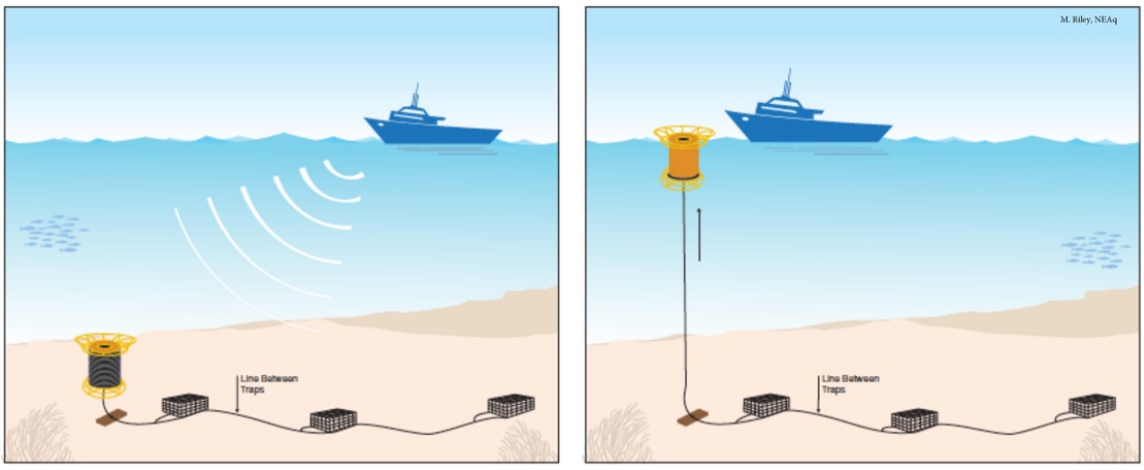


Figure 33: Diagram of the on-call flotation spool.

Figure 34: Left: Spool on fishing vessel: Right: Spool being hauled on deck.

Figure 35: Spool at surface after being released from depth acoustically.

2.10.3.8 Project: Simulating whale entanglements

Project Full Title: Simulating whale-rope encounters using two different computer modelling tools

Project Timeframe: September 2018 – December 2020

Institution(s): ACCOL (NEAq), Bellequant Engineering, Jud DeCew (Consultant)

Contact person: Tim Werner, twerner@neaq.org

Links: https://www.bycatch.org/project/modeling-right-whale-entanglements; https://www.bycatch.org/articles/development-and-evaluation-reduced-breaking-strength-rope-reduce-large-whale-entanglement

Summary:

Aim: This project uses computer modelling techniques to simulate encounters between digitally created endangered species and fishing gear, and to determine sufficient rope loads of modified fishing gear.

It is impossible within any reasonable timeframe to achieve sufficient statistical power for evaluating the effectiveness of a gear treatment deployed in the field when testing it on a small population. This is the case, for example, with endangered species such as the North Atlantic right whale, which only numbers some 400 individuals, and that ranges from Florida to the Canadian Maritimes. Conservation threat level and protected status can also hinder acquisition of permits to test new gear. An alternative approach is to simulate gear encounters using computer modelling techniques.

Results/Status: Based on an analysis of ropes retrieved from baleen whales in the northwest Atlantic, our research group and colleagues showed that ropes with a breaking strength of 1700 lbf or less would be more likely to reduce the incidence and severity of entanglements in pot ropes (Figure 36; Knowlton et al. 2016: https://conbio.onlinelibrary.wiley.com/doi/full/10.1111/cobi.12590). The next phase of the research was to determine how practical it is to fish using ropes with this reduced breaking strength. The results from a field trial showed that these ropes fished reliably (Knowlton et al. 2018, State of MA), however they have not yet been tested in the heaviest and deepest strings of pots fished far offshore, in which the number of pots attached by a single groundline can number 50 or more.
Future: Additional analysis is being carried out using a modified version of *Orcaflex* software to study loads on fishing ropes under different fishing scenarios.

Besides studying the loads on ropes when fishing, this project is using the Whale Entangler program to understand the dynamics of whale entanglement events, load measurements on ropes during these events, and the outcomes of encounters involving ropes of different construction and spacing of "weak points". A description of the computer model (Figure X.8) is available in Marine Mammal Science: https://www.bycatch.org/articles/simulation-entanglement-north-atlantic-right-whale-eubalaena-glacialis-fixed-fishing-gear).

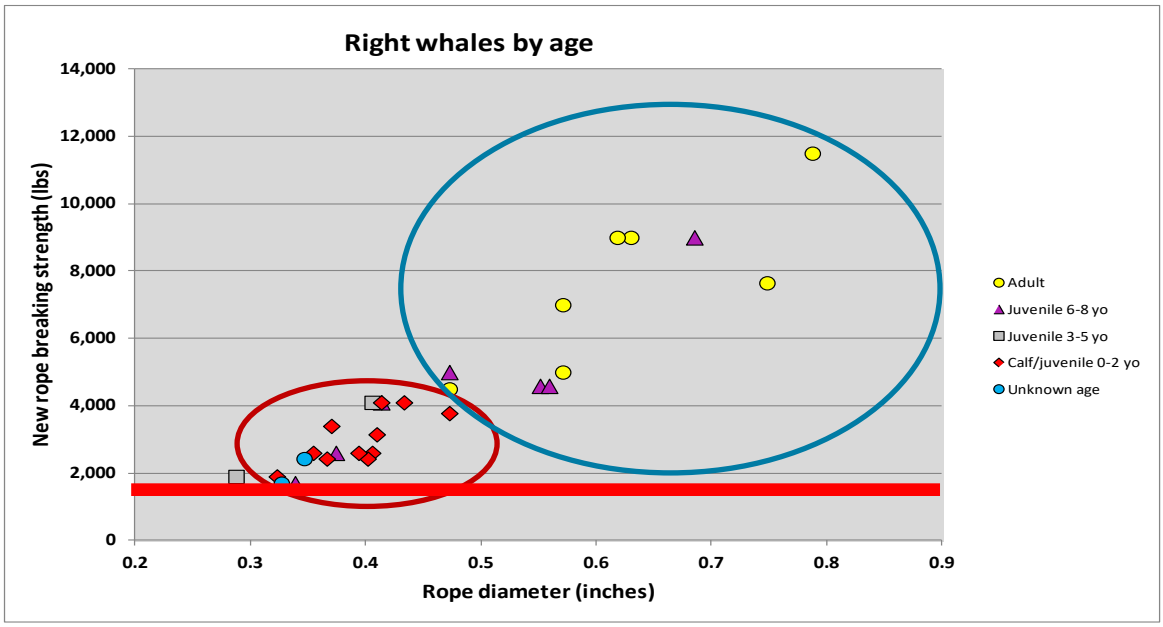


Figure 36: Observed right whale entanglements in which ropes were sampled (1994-2010).

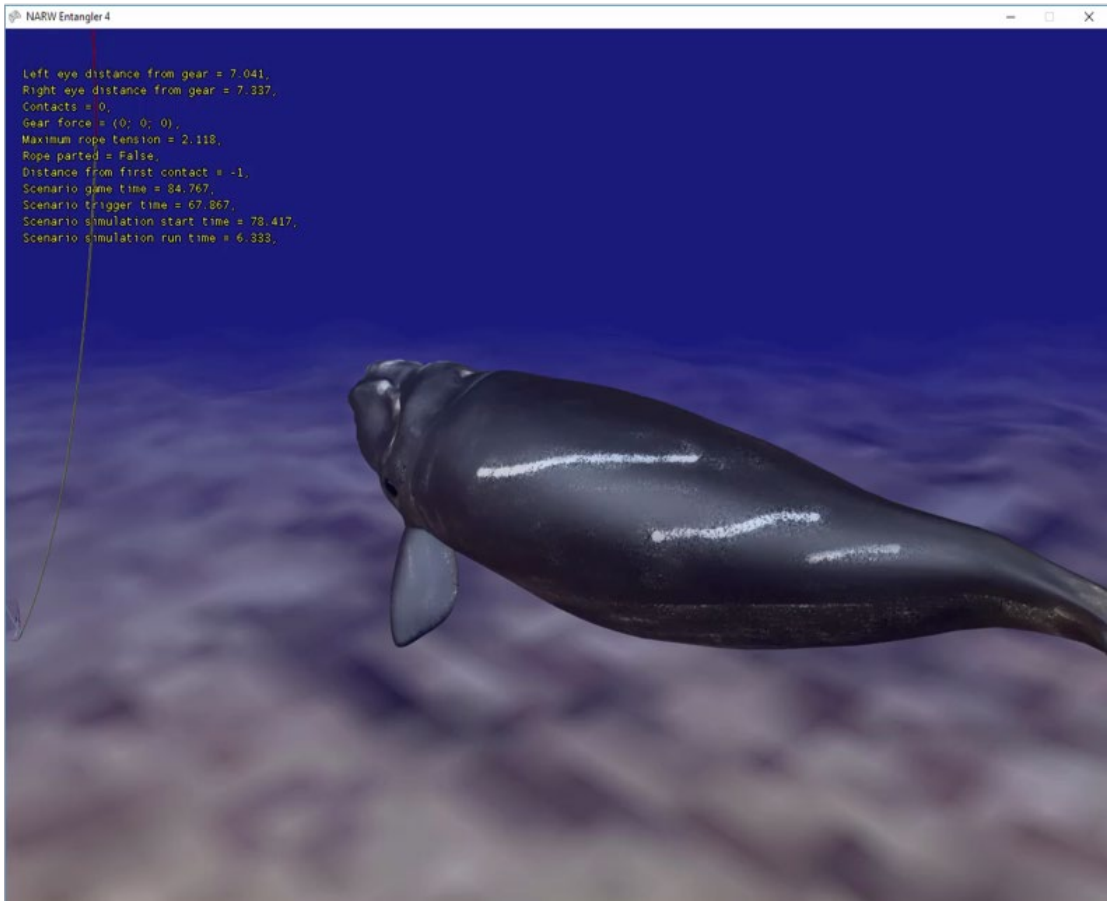


Figure 37: Screen capture of the Whale Entangler program.

2.10.3.9 Project: Collapsible fishing pots

Project Full Title: Testing collapsible fish traps as an alternative to gillnets in a small-scale Argentinian fishery

Project Timeframe: January 2019 – January 2021

Institution(s): ACCOL (NEAq), Aquamarina (Argentina)

Contact person: Tim Werner, twerner@neaq.org

Links: https://www.bycatch.org/project/franciscana-dolphin-bycatch-reduction-research-argentina

Summary:

Aim: This project is examining whether or not alternative gear (fish traps) might produce a comparable CPUE while also limiting bycatch. Gillnets cause unsustainable catch levels of Fransicana dolphin, a coastal species that ranges from mid-coast Brazil to northern Argentina. Acoustic pingers are effective in reducing bycatch however there are a number of concerns about their widespread use.

Results/Status: Collapsible fish traps were manufactured by INIDEP (Argentina) (Figures X.9, X.10). Preliminary deployments (510 for gillnets and 710 for pots) showed comparable catch percentages of the two principal commercial species, whitemouth croaker and striped weakfish (Figures X.11). No dolphins were caught in traps while 26 and 1 sea turtle were killed in gillnets. Although the traps caught equivalent percentages of the two main commercial species, the size class of whitemouth croaker was much smaller.

Future: Additional trials will attempt to increase the capture rate of the desired size class.

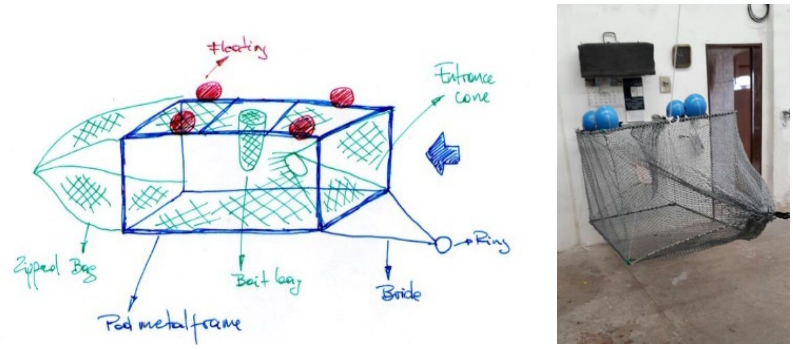


Figure 38: Left: A diagram of the collapsible fish trap.; Right: The collapsible fish trap

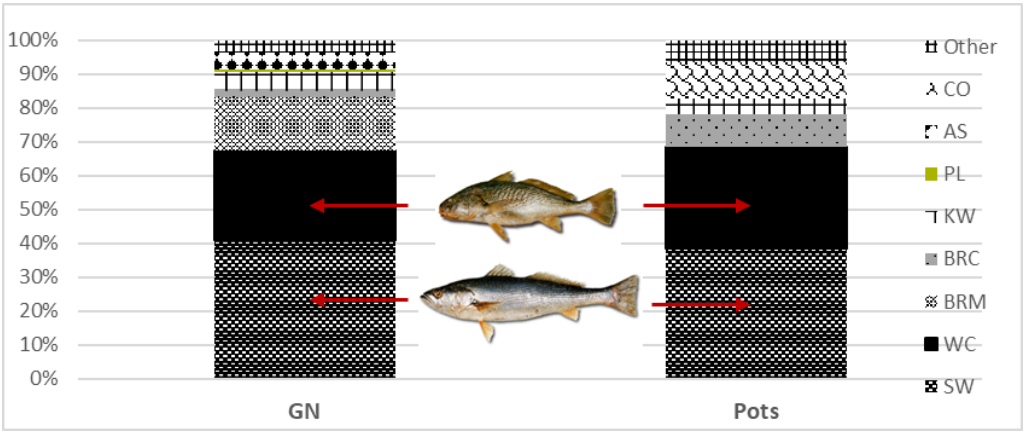


Figure 39: Percentage of species caught in gillnets (GN) and traps (Pots).

2.10.3.10 Project: Use of Artificial Illumination to Reduce Pacific Halibut Bycatch Before Trawl Capture in a U.S. West Coast Groundfish Bottom trawl

Project Full Title: Use of Artificial Illumination to Reduce Pacific Halibut Bycatch Before Trawl Capture in a U.S. West Coast Groundfish Bottom trawl

Project Timeframe: August 2018 – June 2020

Institution(s): Pacific States Marine Fisheries Commission; Oregon State University, Cooperative Institute for Marine Resources Studies; SINTEF Fisheries and Aquaculture; University of Tromsø; International Pacific Halibut Commission; National Marine Fisheries Service, Northwest Fisheries Science Center; F/V *Last Straw*; Foulweather Trawl

Contact person: Mark J.M. Lomeli, mlomeli@psmfc.org

Summary:

In the U.S. West Coast groundfish bottom trawl fishery, Pacific halibut (*Hippoglossus stenolepis*) bycatch can impact some fishers' ability to fully utilize their quota shares of target groundfish. In this study, we compared the catch efficiency for Pacific halibut and four commercially important groundfish species between an unilluminated trawl and a trawl with illumination along its wing tips and upper bridles. Results show the illuminated trawl caught significantly fewer Pacific halibut than the unilluminated trawl. This result translates to significantly fewer Pacific halibut exposed to capture-escape processes within the trawl which can cause physiological stress, fatigue, injuries and lead to unobserved and unaccounted post-release mortality. For target groundfish, results show no significant catch efficiency effect of changing from unilluminated to illuminated trawl for lingcod (*Ophiodon elongatus*), Dover sole (*Microstomus pacificus*), and petrale sole (*Eopsetta jordani*). A significant catch efficiency effect was noted for sablefish (*Anoplopoma fimbria*) with the illuminated trawl catching fewer fish on average. Our results contribute new data on how artificial illumination can affect catches of Pacific halibut and four commercially important groundfish species. In addition, physiological parameters of Pacific halibut caught between the illuminated and unilluminated trawl were collected and analysed. While our results have obvious implications to the West Coast groundfish bottom trawl fishery, our findings could have potential applications in Alaska groundfish bottom trawl fisheries, such as the eastern Bering Sea directed flatfish fishery and Pacific cod (*Gadus macrocephalus*) fishery, where Pacific halibut bycatch also occurs.

Publication: Lomeli, M.J.M., Wakefield, W.W., Herrmann, B., Dykstra, C., Simeon, A., Rudy, D., Planas, J.V. Use of Artificial Illumination to Reduce Pacific Halibut Bycatch Before Trawl Capture in a U.S. West Coast Groundfish Bottom trawl. In: G.H. Kruse, C. Rooper, R. Novikov, and J. Planas (eds.), Integrating biological research, fisheries science and management of Pacific halibut (*Hippoglossus stenolepis*) across the North Pacific Ocean. Fish. Res. *Under review*.

2.10.3.11 Project: Altering the level of artificial illumination on a bycatch reduction device integrated into a Pacific hake midwater trawl and it effect on Chinook salmon bycatch

Project Full Title: Altering the level of artificial illumination on a bycatch reduction device integrated into a Pacific hake midwater trawl and its effect on Chinook salmon bycatch

Project Timeframe: August 2018 – June 2020

Institution(s): Pacific States Marine Fisheries Commission; Oregon State University, Cooperative Institute for Marine Resources Studies; National Marine Fisheries Service, Northwest Fisheries Science Center; F/V *Raven*; Foulweather Trawl

Contact person: Mark J.M. Lomeli, mlomeli@psmfc.org

Summary:

This study examined how bycatch rates of Chinook salmon (*Oncorhynchus tshawytscha*) could be affected by altering the level of artificial illumination on a salmon excluder integrated into a Pacific hake (*Merluccius productus*) midwater trawl. We compared the bycatch rates of Chinook salmon between an unillumined trawl and trawls illuminated with 16 and 32 LED fishing lights along the escape area of the salmon excluder. Blue LED fishing lights, wavelength centered on 464 nm, were used as the artificial light source. Gear trials occurred from July through October 2019 aboard the F/V *Raven*. Preliminary results show bycatch rates of Chinook salmon in the illuminated trawls were considerably lower than in the unilluminated trawl. Between the two levels of artificial illumination, Chinook salmon bycatch rates were similar. For Pacific hake, confidence intervals around the mean modeled catch rate value indicate that there is no difference in their catches between the unilluminated and illuminated trawls. Final results from this study will contribute new data on how artificial illumination can affect Chinook salmon bycatch in the Pacific hake fishery.

2.10.3.12 Project: Evaluating the role of bycatch reduction device design and fish behaviour on Pacific salmon (*Oncorhynchus* spp.) escapement rates from a pelagic trawl

See related project "Flow Analysis of a Funnel-style Salmon Excluder" in National Report, Germany (Karsten Breddermann, karsten.breddermann@uni-rostock.de)

Project Timeframe: August 2018 – January 2020

Institution(s): National Oceanic and Atmospheric Administration, Alaska Fisheries Science Center

Contact person: Noëlle Yochum, noelle.yochum@noaa.gov

Summary:

Mitigating Pacific salmon (*Oncorhynchus* spp.) bycatch is a significant driver in the management of walleye pollock (*Gadus chalcogrammus*) pelagic trawl fisheries in the North Pacific. Various bycatch reduction devices that permit salmon to escape from the trawl ('excluders') have been developed. High variability in escapement rates underscore a lack of understanding regarding mechanisms that promote escapement. We developed a novel excluder (the 'Rope Tube & Funnel Excluder') using computational fluid dynamics simulations and flume tank testing (Figure 40). This process expedited development by producing quantitative flow and net mensuration data, and reasonably predicted performance at full scale under commercial conditions (see Breddermann et al. 2019). During at-sea trials, salmon escapement rates were high (mean 0.58 ± 0.18); however, more comprehensive testing is needed over a breadth of fishing conditions to evaluate practical efficacy. Video footage revealed that salmon disproportionately escaped by swimming

forward from aft of the excluder during haulback and turns, and that the design provided easy and ample access to escapement areas, allowing salmon to both volitionally (swim) and passively (tumble out) escape. Despite efforts to increase perceptibility of escapement areas and to provide sufficient access to them, salmon were retained. This highlights the importance of understanding and affecting the motivation of salmon to escape when designing a salmon excluder (see Yochum et al. *in prep*).

Future research will be conducted to test this excluder over a range of commercial fishing conditions to assess variability in escapement rates. We will also focus on methods to quantify loss of the target species as we adjust the size of the open escapement area, while also testing the effect of adding artificial lights to the rope tube. In addition, we will evaluate salmon behaviour between the excluder and codend. It is unknown at what point salmon turn around and move forward, nor what is motivating them to do this. Results from these additional tests will aid in finalizing the excluder design, which will also take into consideration feasibility of construction and installation by net makers and durability.

Further reading:

Breddermann, K., Stone, M., and Yochum, N. 2019. Flow analysis of a funnel-style salmon excluder. In Contributions on the theory of fishing gear and related marine systems. Proceedings of the 14th International Workshop on Methods for the Development and Evaluation of Maritime Technologies (DEMaT), 5-7 November, 2019. Izmir, Turkey, pp. 29- 42. Ed. by M. Paschen and A. Tokaç

Yochum, N., M. Stone, K. Breddermann, B. Berejikian, J. Gauvin, and D.J. Irvine. *In prep*. Evaluating the role of bycatch reduce device design and fish behaviour on Pacific salmon (*Oncorhynchus* spp.) escapement rates from a pelagic trawl.

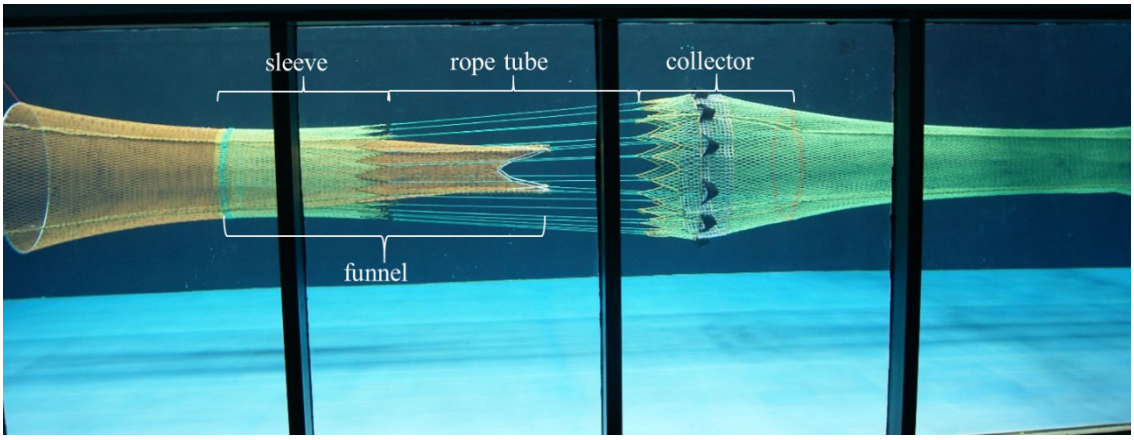


Figure 40: Photograph taken of a candidate excluder design in the flume tank as part of the process to develop the 'Rope Tube & Funnel Excluder'. The figure highlights the main sections of the salmon excluder design: sleeve, funnel, rope tube, and collector. This scaled model was configured based on the initial design concept, which was developed using computational fluid dynamics simulations. Following the flume tank testing, a full-scale design was tested at sea to quantify salmon escapement and evaluate the excluder under fishing conditions.

2.10.3.13 Project: Reducing seabird bycatch through increased longline hook sink rate

Project Full Title: Practicality, safety and economic viability of alternative branchline weighting designs to reduce seabird catch risk in pelagic longline fisheries

Project Timeframe: August 2019 – July 2020

Institution(s): Pelagic Ecosystem Research Group; The Safina Center

Contact person: FisheriesResearchGroup@gmail.com

Summary:

Capture in global pelagic longline fisheries threatens the viability of some seabird populations. Bait loss to scavenging seabirds and catching seabirds reduces fishing efficiency. Branchline weight amount and distance from the hook significantly affect seabird catch rates during setting and hauling. This study identified alternative designs to place branchline weights at the hook instead of conventional designs which can locate weights anywhere from half a meter to several meters from the hook. The study surveyed longline fishers to obtain perspectives on the relative practicality, safety and economic viability of the alternative branchline weighting designs, and conducted a demonstration fishing trip to explore the commercial viability of an integrated weight and hook, where a leaded swivel is attached directly to the eye of the hook, determined from the surveys to hold the most promise. Findings identify candidate branchline weighting designs potentially suitable for use in global tuna longline fisheries to contribute to the effective and commercially viable mitigation of seabird bycatch.

2.10.3.14 Project: Reducing seabird bycatch through increased longline hook sink rate

Project Full Title: Practicality, safety and economic viability of alternative branchline weighting designs to reduce seabird catch risk in pelagic longline fisheries

Project Timeframe: August 2019 – July 2020

Institution(s): Pelagic Ecosystem Research Group; The Safina Center

Contact person: FisheriesResearchGroup@gmail.com

Summary:

Capture in global pelagic longline fisheries threatens the viability of some seabird populations. Bait loss to scavenging seabirds and catching seabirds reduces fishing efficiency. Branchline weight amount and distance from the hook significantly affect seabird catch rates during setting and hauling. This study identified alternative designs to place branchline weights at the hook instead of conventional designs which can locate weights anywhere from half a meter to several meters from the hook. The study surveyed longline fishers to obtain perspectives on the relative practicality, safety and economic viability of the alternative branchline weighting designs, and conducted a demonstration fishing trip to explore the commercial viability of an integrated weight and hook, where a leaded swivel is attached directly to the eye of the hook, determined from the surveys hold the most promise. Findings identify candidate branchline weighting designs potentially suitable for use in global tuna longline fisheries to contribute to the effective and commercially viable mitigation of seabird bycatch.

2.10.4 Future projects and Ideas

2.10.4.1 Project: SouthernHake

Project Full Title: Bycatch Reduction of Red Hake in the Southern New England Silver Hake Trawl Fishery

Estimated Project Timeframe: August 2019 – December 2020

Institution(s): Massachusetts Division of Marine Fisheries; School for Marine Science and Technology – Univ. of Massachusetts Dartmouth

Contact person: David Chosid, david.chosid@mass.gov

Collaboration welcome?: NA

Funding secured?: Y

Summary:

Red hake *Urophyscis chuss* has been a welcome bycatch in the silver hake *Merluccius bilinearis* trawl fishery, but the southern stock of red hake is in declining status. To reduce red hake bycatch in this fishery, we are testing a large mesh belly panel that extends from the fishing line back about 3 m (20 ft) using 38.1 cm (15-inch) meshes, based on observations of red hake low in trawls. We will use the same color for the panel as the surrounding twine to camouflage the opening from silver hake, under the assumption that silver hake are more active and reactive than red hake. Paired comparison to a standard commercial silver hake trawl is planned for April and May of 2021 due to delays related to the global pandemic.

2.10.4.2 Project: Development and testing of a rockfish bycatch reduction device for the Pacific hake fishery: A collaborative study between fishing industry and gear researchers

Project Full Title: Development and testing of a rockfish bycatch reduction device for the Pacific hake fishery: A collaborative study between fishing industry and gear researchers

Estimated Project Timeframe: September 2019 – February 2021

Institution(s): Pacific States Marine Fisheries Commission; Oregon State University, Cooperative Institute for Marine Resources Studies; Midwater Trawlers Cooperative, Pacific Whiting Conservation Cooperative, Shoreside Whiting Cooperative, United Catcher Boats, Whiting Mothership Cooperative, National Marine Fisheries Service, Northwest Fisheries Science Center; Foulweather Trawl

Contact person: Mark J.M. Lomeli, mlomeli@psmfc.org

Collaboration welcome?: NA

Funding secured?: Y

Summary:

In the Pacific hake (*Merluccius productus*) fishery, bycatch of rockfish (*Sebastes* spp.) such as Pacific ocean perch (*S. alutus*), and darkblotched (*S. crameri*), widow (*S. entomelas*), and canary (*S. pinniger*) rockfish has been an ongoing issue facing the fishery. In the early 2000's, these stocks were declared overfished and rebuilding strategies were established. The rebuilding strategies, developed and executed between management and industry, have been effective as these stocks have recently been rebuilt above managements target level of B40% (% of unfished spawning biomass). However, as the biomass of these stocks have increased so have their interactions in the fishery. As a result of these increased interactions and bycatch rates, these stocks continue to

constrain the fishery as their allocations across the fishery still remain relatively low when compared to the Pacific hake allocation. Further, when rockfish are present in considerable numbers, vessels are often forced to move off productive fishing grounds to avoid exceeding their allocation for rockfish. While moving to different fishing grounds may minimize bycatch of rockfish, it can result in moving to areas where Pacific hake abundances are considerably lower and/or are of sizes of lesser or non-marketable value. Under these situations, fishers' cost efficiency to harvest Pacific hake can be substantially impacted. Hence, this problem has resulted in the need to develop and adapt techniques that can reduce rockfish bycatch in the Pacific hake fishery. The objectives of this upcoming project are: 1) conduct a collaborative workshop with Pacific hake fishery participants, gear manufacturers, gear researchers, stakeholders, regional agencies, and management entities to discuss and identify gear modifications that can reduce rockfish bycatch, and 2) undergo sea trials with a rockfish bycatch reduction device developed from the workshop and evaluate its potential efficacy to reduce rockfish bycatch in the fishery. Gear trials will occur during the 2020 Pacific hake fishery.

3 Other business

3.1 Meeting date and venue

WGFTFB proposes that its 2021 meeting will be in Bergen, Norway from 19-23 April 2021. This meeting will be held in association with WGFAST and JFTAB.

3.2 Topic groups for the 2021 WGFTFB meeting

Two Topic Group will pass on the work to the next year (skipping the year 2020 when the meeting was cancelled): a) the light topic group going for the third year and the passive topic group for the second year. At the meeting in 2019, a new Topic Groups was suggested; New Manual of Methods of Measuring the selectivity of towed gears. While the WGFTFB-meeting 2020 was cancelled, the discussions about this TG was continued within the working group and with ICES. As a result, it was decided to establish a new ICES working group "Working Group on Size and Species Selection Experiments (WGSSSE)", chaired by Haraldur Einarsson (FAO/Iceland) and Michael Pol (USA) (see below). Therefore, there will be no new Topic Group on "New manual of methods of measuring the selectivity of towed gears" within WGFTFB.

During the 2019 meeting, another Topic Group or a session was suggested about instruments and new technologies in fishing gear. After discussion, it was agreed it should be proposed to have it as a joint session theme in plenary and therefore not selected as a Topic Group. Finally, a suggestion for a new Topic Group on ETP bycatch mitigation meta-analysis for large pelagic fisheries was proposed during the 2019 meeting. The idea was to develop a database of records from literature to support meta-analyses of capture risk of endangered, threatened and protected (ETP) species. In the discussion, it was mentioned that the topic would appeal to a broader audience to encourage attendance from those that may not otherwise attend WGFTFB meetings. A suggestion to extend from proposed one year to two years was agreed. The members agreed this to be a Topic Group in 2020, which is now postponed to 2021. Therefore, the following topic groups will be active during the 2021 meeting.

3.2.1 ETP Bycatch Mitigation Meta-analyses for Large Pelagic Fisheries (Pelagic)

A WGFTFB Topic Group convened by Eric Gilman (Hawaii Pacific University, USA – EricLGilman@gmail.com), Liming Song (Shanghai Ocean University, China – lmsong@shou.edu.cn), Antonello Sala (Italian Research Council, Antonello.sala@cnr.it), Martin Hall (Inter-American Tropical Tuna Commission, MHall@iattc.org), and potentially additional co-leads, will be formed in 2020 to develop an open source database to support robust meta-analyses of endangered, threatened and protected (ETP) species bycatch mitigation in pelagic fisheries. Due to the larger sample size plus the number of independent studies, correctly designed meta-analyses can provide estimates with increased precision and accuracy overestimates from single studies, with increased statistical power to detect a real effect.

3.2.1.1 Terms of Reference

1. Develop a database of records from compiled literature to support robust meta-analyses on the relative risk of ETP capture by gear design factor. Each database record would include summary statistics required for inclusion in a meta-analysis, including the number of captured organisms by species or higher taxonomic grouping and amount of observed effort, by treatment (e.g. number of leatherback sea turtles caught on pelagic longline circle hooks, and number of circle hooks observed). These records would be derived from publications and grey literature, including from research experiments, at-sea observer programs, electronic monitoring programs, survey fishing, and logbook data. The database would be open source and designed to be a living document, supporting continuous entry of new records making it efficient to conduct updated meta-analyses as new records accumulate.
2. During 2020 the Topic Group will have:
    a) Compiled sufficient records to complete a meta-analysis on the pooled (overall) relative risk of capture of ETP species by pelagic longline bait type (small species of fish, squid species, pieces of incidental catch large pelagic species); and
    b) Will have developed a database structure and entered records from pelagic trawl fisheries.
3. By the WGFTFB 2021 annual meeting, the Topic Group will have finalized and published the database for pelagic longline and pelagic trawl fisheries.

3.2.2 Second year Topic Group: Passive fishing gears (Passive)

A WGFTFB Topic group convened by Peter Ljungberg (Sweden), Isabella Kratzer (Germany) and Lotte Kindt-Larsen (Denmark) was formed in 2019 on passive gears and will continue the work to 2020.

3.2.2.1 Terms of Reference

1. Summarize current and past work in relation to fish pot and trap development, plus gillnet and longline modifications in order to avoid bycatch of protected species (hereunder marine mammals, sea birds and sea turtles).
2. Discuss and describe methods and their limitations, hereunder catch efficiency and depredations risks. Furthermore compare newly developed bycatch mitigation efforts and their efficiency to standard gear and compare different types of passive gears (e.g. gillnets vs. fish pots/traps) and the processes of depredation.

3. Identify and make recommendations on how to improve passive gears including unwanted bycatch, high variability in catches and mitigation of depredation from different predators.
4. Identify potential synergies in developing new approaches to promote sustainability (economically and ecologically) of passive gears

3.2.2.2 Justification

Passive fishing gears such as gillnets, longlines, traps and pots, belong to the most common fishing methods worldwide. These methods have naturally advantages like efficiency, simple use and size selectiveness. Nevertheless, they have been criticized due to bycatches of higher taxa like sea turtles, sea birds and marine mammals, ghost fishing and their vulnerability to depredation by marine mammals. In recent years, a lot of effort has been put into the optimization of fish traps and pots, mainly due to gillnet-raiding seals and studies on how to mitigate bycatch in gillnet and longline fisheries have been carried out with differing success, but a scientifically proven management tool or technical solution working across taxa has yet to be developed. The "Passive" topic group will thus aim to investigate selectivity, efficiency and sturdiness of passive gears, such as gillnets and longlines (mainly species selectivity), fish pots and large-scale fish traps (mainly efficiency and sturdiness). It will document and evaluate current and past work regarding gillnet and longline modifications as well as fish pot and fish trap development. This will include a wide range of fields such as species behaviour, gear design and hydroacoustics. Ongoing and future projects regarding enhanced economical, ecological and social sustainability of passive gears will be discussed and potential synergies identified that will hopefully stimulate new ideas and innovation.

3.2.3 Third year Topic Group: Evaluating the application of artificial light for bycatch mitigation (Light)

A WGFTFB Topic Group convened by Noëlle Yochum (USA) and Junita Karlsen (Denmark) was formed at the 2018 meeting in Hirtshals Denmark, to evaluate the application of light as a mechanism for bycatch mitigation. At the 2019 ICES-FAO WGFTFB meeting the 'Light' Topic Group of experts the group meet for the second year and the final year for the Topic Group is planned to be 2020.

3.2.3.1 Terms of Reference

1. Describe and summarize completed and ongoing research, successes and 'failures', related to the application of light for bycatch mitigation.
2. Identify patterns with respect to species and fishery/ gear types, noting fish behavior in response to light (attraction, repulsion, guidance), and other variables that play a role in the efficacy of using artificial light for bycatch mitigation (e.g. vision, depth, etc.).
3. Describe best sampling techniques for testing the application of artificial light under varying circumstances, including guidance for dealing with common experimental challenges.
4. Highlight areas of needed research in the field of fish behavior with respect to light, and fisheries that might benefit from the application of artificial light.

3.2.3.2 Justification

Essential to the study of fishing gear design and use is fish behavior. The success of bycatch mitigation is linked with understanding how fish interact with fishing gear and respond to the micro-environment in and around the gear. A component of fish behavior that is increasingly being evaluated is the reaction of fish to artificial light. To that end, from 2012-2014, Heui-Chun An, Mike Breen, Odd-Børre Humborstad, and Yoshkiki Matsushita convened a WGFTFB Topic

Group (TG) titled "Use of Artificial Light in Fishing". The focus of this TG was to evaluate the use of artificial light to affect fish behavior and stimulate catch, and to research and synthesize information on fish vision and behavior with respect to light. They also summarized the use of artificial light in fisheries globally and regionally.

The aim of the 2018-2020 'Light' TG is to build on the foundation that has been laid, and to focus on the use of artificial light to enhance bycatch mitigation (e.g. illuminating escape ports or the footrope in trawl gear). Specifically, this TG will focus on creating a community of researchers using light as a fisheries selectivity tool, will develop resources to support this community, and will aggregate and synthesize information from global projects. Through collective review of this research, we will identify variables that play a role in the efficacy of using artificial light for by-catch mitigation (e.g. species, gear type, fish behaviour). We will also discuss common experimental, technological, and analytical challenges when doing this research, and identify gaps in knowledge and other fisheries that might benefit from the application of artificial light. Through the analysis of completed and ongoing research, and collective knowledge of the TG experts, we will also consider guidelines for conducting research on the application of artificial light for by-catch mitigation. We hope that these meetings will also foster an exchange of ideas and support, and stimulate innovation.

3.2.4 Further work to end outstanding work

Topic Group on Factsheets. At the 2019 meeting, it was agreed that the Working Group would decide in plenary whether it would continue producing factsheets. It was agreed that the Topic Group on Factsheets would continue for one more year with a short session/meeting during the 2020 meeting.

Topic Group on GroundGear. The topic group GroundGear ended in 2019 and reported in the 2019 report with conclusions, but no recommendations. During the next meeting (now 2021), the Topic Group on GroundGear will table recommendations for discussion and approval by the topic group and the entire WGFTFB.

3.3 Proposal of new working group (WGSSSE)

A Working Group on Size and Species Selection Experiments (WGSSSE) chaired by Haraldur Arnar Einarsson, Iceland/FAO, and Michael Pol, USA, will be established in 2020 and will work on ToRs and generate deliverables as listed in the Table below.

Year	Meeting Dates	Proposed Venue	Reporting Details	Comments
2020	October TBD	FAO, Rome	Interim report by Dec 2020	
2021	October TBD	FAO, Rome	Interim report by Dec 2021	
2022	October TBD	FAO, Rome	Final report by Dec 2022	

ToR Descriptors

ToR	Description	Background	Science Plan Codes	Duration	Expected Deliverables
a	Identify current areas of the Wileman manual in need of updating or improving	Science Requirements	5.4	1 year (2020-21)	Work plan
b	Draft an outline of the new manual, considering the updating opportunities identified in ToR (a) including data collection, data analysis, and reporting of results.	Science Requirements	5.4	1 year (2020-21)	Outline
c	Establish thematic subgroups with individual chairs to address individual topics (e.g. editing and oversight, field methods, statistical theory and tools, drawings, publishing)	Science Requirements	5.4	2 years (2020-2022)	Chapters of subsections by each subgroup
d	Create a draft manual from all contributions	Science Requirements	5.4	1 year (2022-23)	Draft report
e	Provide preliminary advice on develop of a manual for static gears	Science Requirements	5.4	1 year (2023)	Recommendation

Summary of Work Plan

Year 1	Meet to address areas to be updated in the Wileman manual, develop an outline of the new manual, and create thematic subgroups
Year 2	Bring text together for group editing and approval
Year 3	Produce final draft

Supporting information

Priority	The activities of this group will provide a much-needed update to a primary reference document, ICES Cooperative Research Report No. 215: Manual for Methods of Measuring the Selectivity of Towed Fishing Gears. The Manual is now nearly 25 years old, and was developed before the availability of open-source statistical software and newer statistical methodology accessible due to computing power. ICES Report No. 215 is a foundational document for gear technologists.
Resource requirements	Additional resources to undertake these activities is minimal, and will be drawn from members' institutions
Participants	The Group is expected to consist of at least 10 members, most drawn from WGFTFB
Secretariat facilities	Standard support
Financial	Publishing or hosting of final product, or none
Linkages to ACOM and groups under ACOM	
Linkages to other committees or groups	Annual or more frequent updates to WGFTFB are planned
Linkages to other organizations	FAO Fishing Operations and Technology Branch

Pressure for sustainable exploitation of natural resources is increasing from all sectors of society, triggering the search for better management of human activities. To achieve selective and sustainable fisheries, there is a growing trend among fishing management plans around the world to adopt (catch-) restrictive regulations, often challenging the economical sustainability of the Industry. The bycatch of unwanted species or juvenile fish is today more than ever under the focus, challenging fishing technologists and fishers the developments and use highly selective fishing gears. The search for highly efficient and selectivity gears often lead to complex concept designs, with selectivity properties that only can be accessed and quantified by sophisticated experimental methods and analytical tools. This is especially the case for towed gears, where the application of several selection devices has become a common practice to improve selectivity in mixed fisheries. A brief review of scientific literature shows such a methodological breakthrough occurred during the last years. Unfortunately, it also reveals the out-of-date status of the ICES manual of methods of measuring the selectivity of towed gears (Wileman et al 1996). The ICES manual has been for many years the main reference for students in fisheries science, and the guideline for young and senior scientists to conduct their selectivity studies soundly. However, the current version is no longer the most relevant tool for educational or professional purposes: It misses more than 20 years of development in fisheries science, and therefore does not provide experimental descriptions and/or access to analytical tools required for current research topics.

Consequently, the FTFB community has identified a compelling need to collect, catalogue, describe and make available current methodologies and tools by updating the current manual of methods. These are the main aims of the "Working Group on Size and Species Selection Experiments" (WGSSSE).

This effort is too substantial to be conducted by a subgroup or topic group of WGFTFB. WGFTFB meets on an annual basis and members are often occupied in multiple topic groups that meet concurrently. A new manual will require more frequent meetings and by creating a new WG, all WGFTFB members and others are potentially available to contribute.

3.4 Requests from other WGs

ICES WGBYC (delivered by Kelly Macleod and Sara Königson) requested to collect information on work conducted to evaluate and/or mitigate bycatch of PETS (Protected, Endangered and Threatened Species).

Therefore, it was agreed to collect this information from 2021 onwards. The following lines should be added to each project description in the National reports:

Is the project directly addressing bycatch of PETS*? Yes / No (delete as appropriate)

Could this project indirectly decrease bycatch of PETS*? Yes / No (delete as appropriate)

*Protected, Endangered and Threatened Species = all marine mammal, seabird and turtle species and any protected, prohibited (see Table 1.4 of the WGEF 2019 report for a list of EU-prohibited elasmobranchs) or zero TAC elasmobranchs and protected fish species (see Table 18 WGBYC 2019 report),

3.5 Requests for advice

In 2019, the EU Commission (EU DG-MARE) seeked ICES advice on the progress that has been made, or impact arising from innovative gears within EU waters. This advice should assess the benefits for, or negative effects on, marine ecosystems, sensitive habitats and selectivity. Specifically, and to the extent possible, the advice sought should provide information on what kind of innovative gears are being used, their objective, their technical specificities and the impact on both target species, non-target species and the environment in which they had been deployed.

ICES contacted WGFTFB and it was decided to establish a Workshop on Innovative Fishing Gear (WKING; chair Antonello Sala) to work on this request. The report of WKING can be found here http://www.ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/EOSG/2020/WKING%20Report%202020.pdf

Annex 1: List of participants

As the meeting did not take place, only the chairs and the contact persons for the national reports are listed below (alphabetically order).

Name	Institute	Country (of institute)	Email
Mikel Basterretxea	AZTI	Spain	mbasterretxea@azti.es
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Georg Haney	Marine and Freshwater Research Institute	Iceland	georg.haney@hafogvatn.is
Pingguo He (chair)	Food and Agriculture Organization (FAO) / University of Massachusetts Dartmouth	USA	phe@umassd.edu pingguo.He@fao.org
Pascal Larnaud	Ifremer	France	pascal.larnaud@ifremer.fr
Emma Mackenzie	Marine Scotland Science	Scotland	emma.mackenzie@gov.scot
Mike Pol	Massachusetts Division of Marine Fisheries	USA	mike.pol@mass.gov
Antonello Sala (chair)	Institute of Marine Biological Resources and Biotechnologies (CNR-IRBIM)	Italy	antonello.sala@cnr.it
Daniel Stepputtis (chair)	Thünen Institute of Baltic Sea Fisheries	Germany	daniel.stepputtis@thuenen.de
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Paul Winger	Memorial University/ Fisheries and Marine Institute	Canada	paul.Winger@mi.mun.ca

Annex 2: Resolutions

2019/FT/EOSG08 The ICES-FAO **Working Group on Fishing Technology and Fish Behaviour** (WGFTFB), chaired by Daniel Stepputtis*, Germany, Antonello Sala*, Italy and Pingguo He, USA (on behalf of FAO), will meet to work on the following Terms of References (ToRs) and produce deliverables as listed in the following table for the years 2020 through 2022. WGFTFB will report on the activities and findings by 25 June each year to EOSG.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2020	By correspondence		Interim report by 22 May to EOSG	Incoming Chair Daniel Stepputtis, and Antonello Sala Pingguo He Chair on behalf of FAO
Year 2021	19-23 April	Online Meeting	Interim report by 25 June to EOSG	
Year 2022	To be determined	Potentially Turkey	Final report by 25 June to EOSG	Sponsored by FAO

ToR descriptors

ToR	Description	Background	Science plan codes	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.	3.3, 4.5, 5.4	3 Years	ICES report
b	Organize a FAO-sponsored 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.	2.1, 4.5, 5.4	Year 3	FAO report, ICES report
c	Organize a Joint Workshop on Fishing Technology, Acoustics and Behavior (JTFAB) to review research topics of mutual interest to both the Working Group on Fishing Technology and Fish Behaviour (WGFTFB) and the Working Group on Fisheries Acoustics, Science and Technology (WGFAST).	Every three years, WGFAST and WGFTFB meet for a one-day Joint workshop on Fishing Technology, Acoustics and Behaviour (JFTAB) to review and share information on topics of mutual interest.	3.2, 4.5, 5.4	Year 1	JFATB report

d	Help organize an international fishing technology and fish behaviour symposium or workshop	The last similar symposium was 13 years ago (2006).	2.1, 4.5, 5.4	Fall 2020	Symposium or workshop with proceedings published in a special issue in ICES JMS
e	Support survey working groups with fishing gear expertise upon request	EOSG has identified gear expertise gaps in survey working groups.	3.2	Year 1,2,3	Report of relevant survey trawl working groups or associated 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 WGs
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. FAO has committed to support the WG by sponsoring a WG meeting every third year. There are no additional resource requirements for the EG beyond the secretariat support for group organization
Participants	The group is normally attended by about 60–100 regular members and chair-invited members. Participation is about 100 - 140 in the year when FAO-ICES mini-symposium is held. The numbers of attendees to the meeting have been growing over the last years.
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 EOSG, e.g. WGFAST, and the acoustic survey groups.
Linkages to other organizations	The WG is jointly sponsored with the FAO.