**Final meeting of the ICES WGFTFB 'Light' Topic Group**
**2021 Joint Meeting ICES-FAO WGFTFB/ ICES WGFAST (Norway- online)**
**'Light' Topic Group Agenda and Abstracts**

## 'Light' Topic Group

Title: "Evaluating the application of artificial light for bycatch mitigation"
Conveners: Noëlle Yochum (USA) and Junita Karlsen (Denmark)
Rapporteur/ Time Keeper: Valentina Melli (Denmark)

An ICES- FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB) topic group (TG) of experts was formed to evaluate the use of artificial light as a fisheries selectivity tool to reduce bycatch. This TG met during the WGFTFB annual meetings in 2018 (Denmark) and 2019 (China). The 2021 WGFTFB meeting in Norway (online) will be the final gathering of this TG. Goals for the TG are to:

*i.* form a community of researchers applying light for bycatch mitigation;
*ii.* identify related work that has been and is being done globally;
*iii.* provide background knowledge and develop tools that can be used to support this com munity of researchers; and
*iv.* identify and discuss common challenges when using light as a selectivity tool.

## 2021 'Light' TG Agenda

Below is the 'Light' TG agenda for the meeting on April 20th from 15:00-19:00 (CEST). To attend the 'Light' Topic Group meeting, join via: meet.google.com/och-cgkg-nyg or contact Noëlle Yochum at noelle.yochum@noaa.gov. Note that the TG meeting will not be recorded.

| Time (CEST) | Tuesday 20 April | |
|---|---|---|
| | **Topic Group Session 1** | |
| 15:00-15:15 | Introductions and Topic Group summary | Noëlle & Junita |
| 15:15-15:20 | Update on the 'Light' guidelines paper | Noëlle & Junita |
| 15:20-15:25 | Break | |
| | **Topic Group Session 2** | |
| 15:25-16:25 | Keynote Presentation: "Selective invisibility and its potential applications in fisheries: a case study in reducing sea turtle bycatch by longlines" | Sönke Johnsen |
| 16:25-17:25 | Keynote Presentation: "The colourful world of marine fishes, from tropical coral reefs to the deep-sea" | Fabio Cortesi |
| 17:25-17:30 | Break | |
| 17:30-17:45 | Presentation: "Use of LED light in beam trawl fisheries" | Mattias van Opsdal |
| 17:45-18:00 | Presentation: "An unplanned trial with artificial light revealed a yield increase in crustacean trawl fisheries" | Michele Luca Geraci et al. |
| | **Topic Group Session 3** | |
| 18:00-18:50 | Facilitated group discussion: Where are we at with light and where do we go from here? | Noëlle & Junita |
| 18:50-19:00 | Wrap up | Noëlle & Junita |

## 2021 'Light' TG Abstracts

Below are abstracts for the presentations that will be given during the 2021 WGFTFB meeting relevant to the 'Light' Topic Group. This includes four presentations given during the Topic Group meeting (20 April; two submitted papers and two invited keynote speakers). In addition, there are three relevant presentations that will be given in the WGFTFB plenary (one in the Joint WGFTFB - WGFAST Section on 21 April; and two in the Trawl Selectivity Section on 22 April); and one during the 'Passive Gear' TG (20 April).

Presentations during the 'Light' TG Meeting

- *Keynote Speakers*

**Selective invisibility and its potential applications in fisheries: a case study in reducing sea turtle bycatch by longlines**

- **Sönke Johnsen -** *sjohnsen@duke.edu*

*Duke University, Dept. Of Biology, 301 Bio Sci Bldg, Durham, NC 27708, USA*

The visual systems of animals are under natural and sexual selection and thus vary in capabilities, sometimes dramatically so. This opens the possibility to design lures that are visible to target fisheries species but invisible (or at least less visible) to bycatch. Or conversely, to design an aversive visual stimulus that is only visible to the bycatch species. Successful implementation of either approach requires knowledge of the various aspects of the visual systems of both the target and bycatch species and of the optical environment in waters of the appropriate type and depth. As a case study, this talk examines whether it is possible in theory at least to design longline lures that are highly visible to longline target species (e.g. Swordfish) but cryptic to sea turtles. The spectral sensitivity range, color vision, spatial acuity, and temporal resolution of a number of longline targets and sea turtle species were collated from concurrent research projects and then examined in the context of a modeled oceanic light environment. It was found that the most successful strategy takes advantage of the slower temporal resolution of sea turtles relative to longline targets, with the ideal lure being one that consisted of blinking light-emitting-diodes that rapidly alternated between two colors that mixed to create an average color that matched the background space light. The alternation frequency is set so that it is above what the sea turtles can discern but still distinguishable as individual colors by the longline targets.

**The colourful world of marine fishes, from tropical coral reefs to the deep-sea**

- **Fabio Cortesi -** *F.cortesi@uq.edua.au*

*The University of Queensland, Queensland Brain Institute, 4072 St Lucia, QLD, Australia*

Imagine living a thousand meters below sea level surrounded by darkness but for a few bioluminescent rays of light. Now imagine living in a clear mountain lake, three thousand meters above sea level, where the plethora of light can cause blindness anytime. There are many examples of fishes that have adapted their visual systems to cope with different light conditions, yet, the molecular basis for these adaptations and how this translates to their day-to-day life remain poorly understood. At the core of fish vision lie the opsin proteins that together with a chromophore form the light-sensitive photopigments. The vertebrate ancestor already possessed five such opsins (four cone and one rod opsin) that were sensitive from the ultraviolet to the red light. In teleosts in particular, opsins continued to proliferate

and to diversify. Why fishes have so many different opsins is not entirely clear, but correlations can be drawn with their ecologies, behaviours and species-specific light habitats. Here, I aim to give an insight into our current understanding of teleost visual ecology. Providing a general overview and then focusing on deep-sea and coral reef fishes in more detail, I will showcase some of our recent findings and will highlight how recent technological advances can be leveraged to quickly and efficiently increase our knowledge.

- *Submitted Papers*

**Use of LED-light in beam trawl fisheries**


- **Mattias Van Opstal -** *mattias.vanopstal@ilvo.vlaanderen.be*

*Institute for Agricultural and Fisheries Research (ILVO), Animal Sciences - Fisheries, Ankerstraat 1, 8400 Oostende, Belgium*


The introduction of the landing obligation poses a major challenge for the Belgian fishing sector, since it mainly practices mixed beam trawling. In order to assist the sector in dealing with the landing obligation, ILVO and Rederscentrale intend to reduce the catch of choke species and other bycatch in beam trawling and improve survival in the "Combituig" project through the development and refinement of technical innovations.

In this project, different innovations were tested to reduce choke species and other bycatch species in the net. One of the most promising innovations focused on the use of LED-light ropes in different positions in the net. During the past 2 years, several catch comparison trials were performed on board of the RV Belgica with LED-lights attached to the beam, a discard release panel (DRP) and a benthos release panel (BRP). Extra cod-ends covering the DRP and BRP were used to quantify the LED-light induced escape of different species. First results indicate that LED-lights might be an effective tool to reduce bycatch of plaice in beam trawl fisheries targeting sole.

**An unplanned trial with artificial light revealed a yield increase in crustacean trawl fisheries**


- **Michele Luca Geraci[1,2] -** *micheleluca.geraci2@unibo.it*
- **Danilo Scannella[2], Fabio Falsone[2], Giacomo Sardo[2], Vita Gancitano[2], Francesco Colloca[3], Fabio Fiorentino[2] and Sergio Vitale[2]**

*[1]Department of Biological, Geological and Environmental Sciences (BiGeA), University of Bologna, Piazza di Porta San Donato 1, 40126 Bologna, Italy;*

*[2]National Research Council - Institute of Marine Biological Resources and Biotechnologies (CNR - IRBIM), Via Luigi Vaccara 61, 91026 Mazara del Vallo (Tp), Italy*

*[3]Stazione Zoologica Anton Dohrn, Integrative Marine Ecology Department, Villa Comunale, 80121 Naples, Italy*


In this preliminary study we tested the efficiency of artificial lights during a selectivity survey carried out, in September 2017, off the SW Sicilian coast. The targeted species were deep water rose shrimp (*Parapenaeus longirostris* Lucas, 1846; DPS) and European hake (*Merluccius merluccius* Linneus, 1759; HKE). A total of 18 repeated nocturnal hauls were conducted across six days (i.e. three hauls per night). During one of these nights three unplanned hauls were carried out with a trawl net equipped with 20 green lights. A comparison of the Catch per Unit Effort (CPUE, kg/h) carried out with Kruskal-Wallis test highlighted a significant increase during hauls with light for DPS, HKE as well as for gross catch. Taking into account the overall size structure of target (DPS) and by-catch species (HKE) of the crustacean trawl fishery, the Kolmogorov Smirnov test pointed out significant differences between hauls with and without light only for DPS. This preliminary results seems to suggest a general attractive effect of artificial lights.

Presentations in Plenary

- *Joint Workshop WGFTFB and WGFAST Section (21 April)*

**Biology of Fish Vision**

- **Anne Christine Utne-Palm -** *anne.christine.utne.palm@hi.no*

*Institute of Marine Research, Norway*

Fish vison is evolved in a very different optical environment than air. Thus, to understand the biology of fish vison one must know something about how sunlight and its different wavelengths propagate in water. Light is absorbed and scattered by particles in the water (e.g. humus, silt, plankton) as well as the water molecule itself, this causes a great variation in light conditions between different parts of the ocean. Blue light travels best in water, as the water molecule itself absorbs the longer wavelengths (red, yellow and green). Humus and alga absorb shorter wavelength (blue light). Nutritious coastal or brackish water is therefore dominated by green, yellow and red light, while clear oligotrophic oceanic water is dominated by blue light. In clear oceanic water the light limit for photosynthetic activity is at ca 200m, while limit for fish vision is at ca 800-1000m depth. The latter is of cause dependent on fish species. It is important not to underestimate available light at fishing depth. It is easy to trust todays PAR sensors that shows no light below 100 to 200m depth, though these sensors are only measuring photosynthetic available light (Photosynthetically Active Radiation =PAR). Deep sea fish are proposed to be 100 times more light sensitive than humans. In general, the light sensitivity of a species matches the dominant wavelength and light intensity in its natural habitat. Mesopelagic fish, living at the depth limit for sunlight, are known to follow a given light intensity (isolume) in their diel vertical migration.

To better understand the may adaptations in teleost's vision, I will give a simplified cartoon description of the structure and function of the teleost eye. How the lens focusses light (photons) on to the retina, and how the photoreceptors in the retina change the energy from electromagnetic radiance (photons) to nerve impulses transmitted, via the optic nerve, to the optical lobe in the brain, where the image is perceived. The photoreceptors are triggered by single photons, thus we should measure light in Einstein's (E), as 1 E = 1 mole of photons. I will shortly explain visual acuity, scotopic threshold and flickering fusion threshold and how these can be measured behaviourally by using optomotor response. An important thing to remember is that both eye size (growth, age) and ambient temperature has a great impact on visual resolution in fish, except for swordfish, tuna and some sharks that have heated eyes. As light intensity quickly diminishes and get more monochromatic by depth, the most important visual task for marine organisms is to detect differences in contrast, between an object and its background. Thus, most marine animals have developed a visual system that enhance contrast detection (of their prey) against the ambient light. Likewise have prey and predators developed surface camouflages that degrades their contrast against their background light, e.g. by having dark dorsal and light ventral colour, reflecting silvery sides, counter illumination (bioluminescence) or transparent body. Accordingly, the evolutionary arms race has evolved visual detection of UV - and polarized light in some fish, a trait that enhances detection of silvery or transparent prey.

- *Trawl Selectivity Section (22 April)*

**Assessing the effects of artificial light on the raised - fishing line in the Celtic Sea mixed demersal trawl fishery**


- **Martin Oliver** - *Martin.Oliver@bim.ie*
- **Matthew McHugh, Daragh Browne, and Ronan Cosgrove**

*BIM, New Docks, Galway, Ireland*


The raised fishing line (RFL) was introduced as a gear option under the remedial measures for cod in the Celtic Sea on June 1st, 2020. Tested and developed in Ireland through a series of gear trials and a flume tank workshop, this gear was shown to significantly reduce cod catches by approximately 40% while retaining market sized haddock and whiting. The RFL is constructed with 1-meter droppers (rope or chain) attached between the ground gear and the fishing line permitting low swimming fish such as cod to escape at the mouth of the trawl. Placing artificial light at the mouth of the trawl may trigger phototactic responses in fish species before they fatigue and enter the net. SafetyNet Technologies "PISCES" unidirectional lights at a green colour setting (~ 520 nm wavelength) were tested on the RFL. The lights were mounted at ~ 1 meters spacing on the fishing line around the bosom of the trawl. Preliminary results based around catch weights from a self-sampling trial are presented.

**The efficacy of illumination to reduce Pacific halibut bycatch in a U.S. West Coast groundfish bottom trawl**


- **Mark J.M. Lomeli[1]** - *mlomeli@psmfc.org*
- **W. Waldo Wakefield[2], Bent Herrmann[3,4], Claude L. Dykstra[5], Anna Simeon[5], Dana M. Rudy[5], and Josep V. Planas[5]**

*[1] Pacific States Marine Fisheries Commission, 2032 SE OSU Drive, Newport, OR 97365, USA*

*[2] Oregon State University, Cooperative Institute for Marine Resources Studies, Hatfield Marine Science Center, 2030 SE Marine Science Drive, Newport, OR 97365, USA*

*[3]SINTEF Ocean, Willemoesvej 2, DK-9850 Hirtshals, Denmark*

*[4] University of Tromsø, Breivika, N-9037 Tromsø, Norway*

*[5] International Pacific Halibut Commission, 2320 W. Commodore Way, Seattle, WA 98199, USA*


The directed commercial fishery for Pacific halibut (Hippoglossus stenolepis) in the U.S. is longline based. In trawl, trap, and other longline fisheries, their bycatch can occur in considerable numbers and retention of these fish is prohibited. Trawl fisheries comprise the majority of Pacific halibut bycatch, tend to encounter younger fish than the directed fisheries, and generally have the highest discard mortality rates. Thus, identifying methods to reduce

their mortality in trawl fisheries is of great importance. In this study, we compared the catch efficiency for Pacific halibut and four groundfishes between an illuminated and non-illuminated trawl in the U.S. West Coast groundfish bottom trawl fishery. The illuminated trawl caught significantly fewer Pacific halibut and sablefish (Anoplopoma fimbria) than the non-illuminated trawl. For Dover sole (Microstomus pacificus), petrale sole (Eopsetta jordani), and lingcod (Ophiodon elongatus), the illuminated trawl caught fewer individuals
than the non-illuminated trawl. However, this result was not statistically significant. Physiological data collected on Pacific halibut show blood levels of cortisol, a stress hormone, were significantly higher in fish caught in the illuminated trawl. Future research direction and discussion on how trawl design may affect the efficacy of illumination to reduce Pacific halibut bycatch will be discussed.

Presentation during the 'Passive Gear' TG

**Artificial LED-lights increase the catch efficiency of snow crab (*Chionoecetes opilio*) pots**


- **Kristine Cerbule[1]** - *kristine.cerbule@sintef.no*
- **Bent Herrmann[1,2,3], Eduardo Grimaldo[1,2], Leif Grimsmo[1], Jørgen Vollstad[1]**

*[1] Department of Fisheries Technology, SINTEF Ocean, Trondheim, Norway;*
*[2] UiT The Arctic University of Norway, Tromsø, Norway*
*[3] DTU Aqua, Hirtshals, Denmark*



In commercial snow crab (*Chionoecetes opilio*) fisheries, the catch efficiency of the conical pots, such as those used in the Barents Sea and Canadian waters, is important for increasing the profitability of the industry. This study evaluated the effect of adding green and white light emitting diodes (LED) on the catch efficiency of commercially used conical pots. The results from the field experiments showed that inserting artificial lights significantly increases the catch efficiency for snow crab over the minimum landing size of 95 mm in carapace width of up to 76% when using green LED, and by 52-53% on average when using white LED. This study shows that it is possible to improve the catch efficiency of the snow crab fishery by applying artificial LED lights to the conical snow crab pots, potentially resulting in an important economic benefit to the snow crab fishery.