

How artificial lights affect bycatches of fish and the Deep-water shrimp during trawling in the Barents Sea

Roger B. Larsen¹, Bent Herrmann^{1,2}, Manu Sistiaga², Jesse Brinkhof¹, Ivan Tatone¹, Lise Langård³ and Jure Brčić⁴.

¹ The Arctic University of Norway, UiT, Breivika, N-9037 Tromsø, Norway,

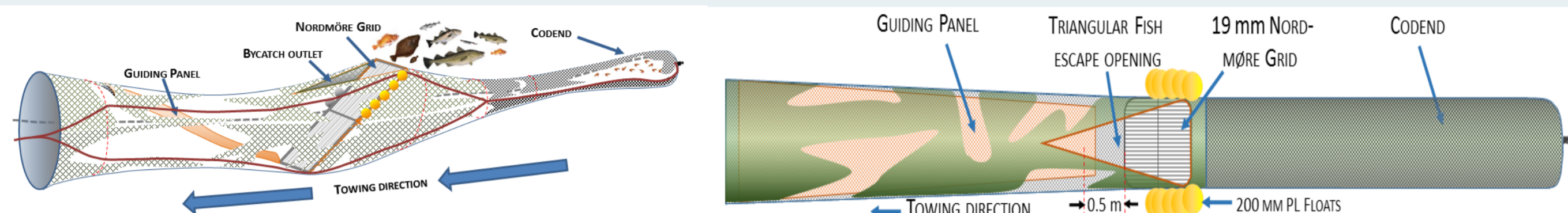
² SINTEF Ocean, Brattørkaia 17C, N-7010 Trondheim, Norway,

³ Norwegian Directorate of Fisheries, Postbox 185 Sentrum, 5804 Bergen, Norway,

⁴ University of Split, Department of Marine Studies, 21000 Split, Croatia

BACKGROUND

The Nordmøre grid, as used in Norway with 19 mm bar spacing, will reduce a large proportion of the bycatch of fish species. The bycatch is therefore small-sized fish species and juveniles that are able to pass through the grid and enter the codend, along with the targeted Deep-water shrimp (*Pandalus borealis*). The bycatch of fish not only leads to additional sorting work onboard, but it clearly has negative impact on the ecosystem due to increased fish mortality. A minor proportion of small fish and juveniles will escape through the outlet above the grid, without making contact with the grid itself.



The working principle of a Nordmøre grid bycatch excluder system and design details



Bycatch limits/10 kg shrimps:

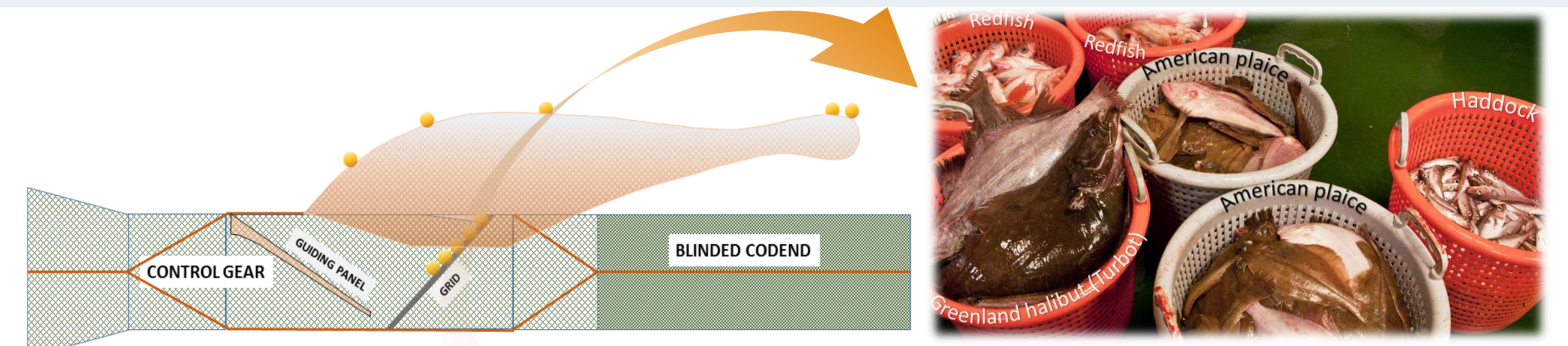
- 8 cod (*Gadus morhua*),
- 20 haddock (*Melanogrammus aeglefinus*),
- 3 redfish (*Sebastes* spp),
- 3 Greenland halibut (*Reinhardtius hippogly.*),
- 10% shrimp below 15 mm carapace length

The current bycatch problem and regulations for the Barents Sea (Northeast Atlantic).

THE EXPERIMENTAL DESIGN

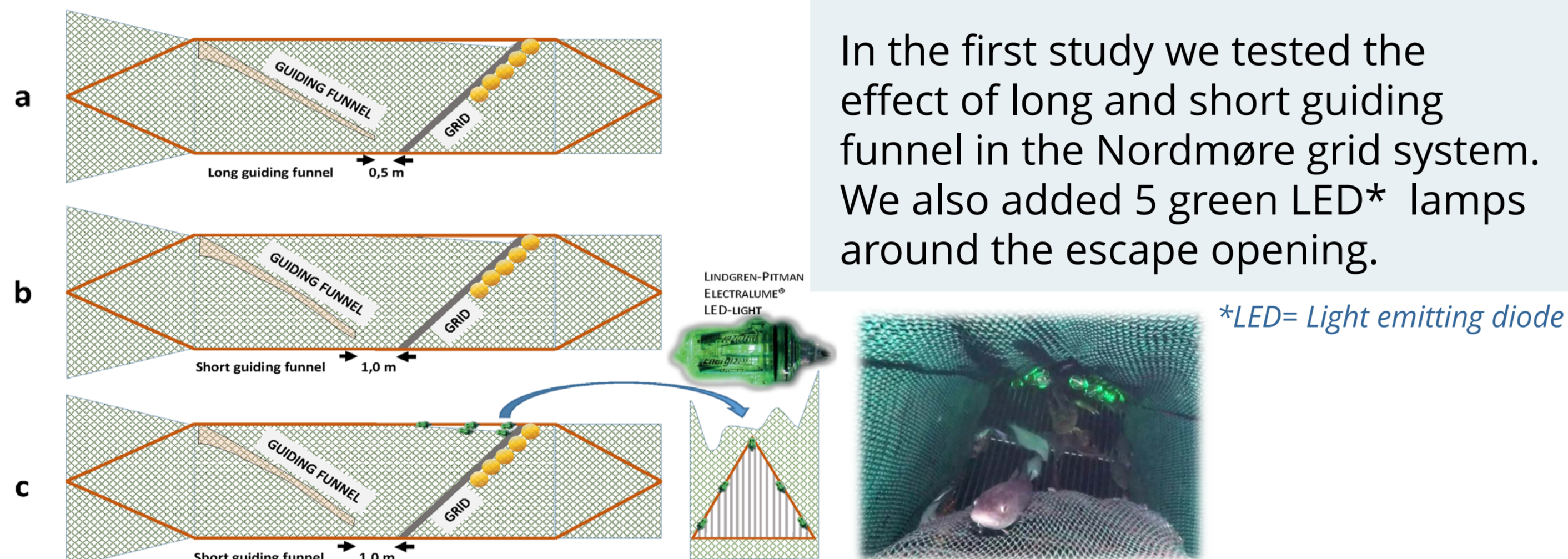
We conducted experimental fishing trials over two periods to assess the size selective properties of the 19 mm bar spaced Nordmøre grid with and without LED lamps. A small-meshed cover was used to retain escaping fish. We investigated if introduction of LED lamps could promote the escape behavior and potentially reduce bycatch in shrimp trawl fisheries.

Both studies were made in the Northeast Atlantic (N76°-E32°) during the 24 hour dark-period (sun below horizon) at depths 360-380 m. The first study was done during February and the second one during November 2016.



The Nordmøre grid section with cover over the bycatch escape opening and examples of bycatch species (and sizes) being excluded from the Northeast Atlantic shrimp fishery

THE FIRST STUDY: GREEN LED LAMPS AROUND THE ESCAPE OUTLET OF THE NORDMØRE GRID



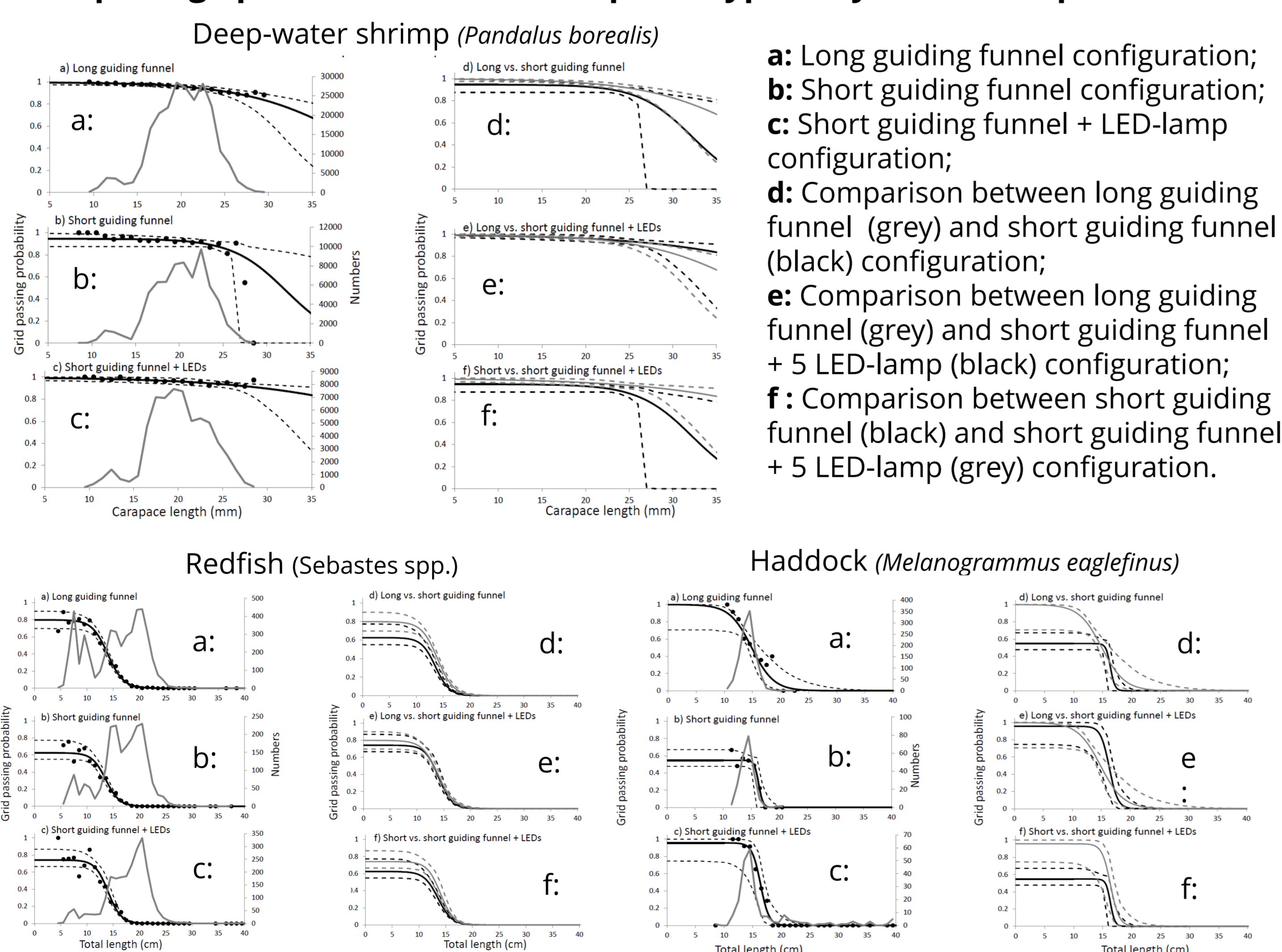
In the first study we tested the effect of long and short guiding funnel in the Nordmøre grid system. We also added 5 green LED* lamps around the escape opening.

*LED= Light emitting diode

Study I: We investigated the selective properties for Deep-water shrimps and bycatch species of fish with a Nordmøre grid system that had:

- A long guiding funnel (which ends 0.5 m in front of the grid).
- A short guiding funnel (which ends 1 m in front of the grid).
- A short guiding funnel with five LED's attached around the escape opening.

Grid passage probabilities for shrimp and typical bycatch fish species:



Note: Similar patterns were found for cod (*Gadus morhua*) and American plaice (*Hippoglossoides platessoides*).

Dots represents experimental rates, solid curve the fitted model and stipple curves the 95% confidence bands for the curve.

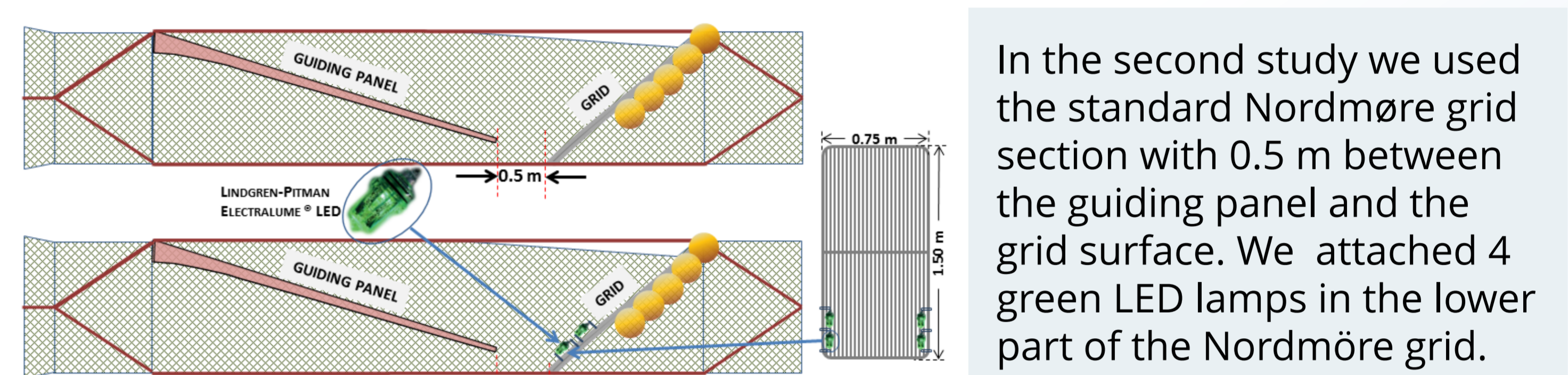
RESULTS AND CONCLUSION

Very few Deep-water shrimps were found to escape through the escape opening although the quantity increased slightly at larger sizes. Between 80% and 100% of the bycatch species up to a species-specific size passed through the grid and entered the codend.

A short guiding funnel decreased this for haddock significantly by increasing the fraction of small haddock seeking the escape opening.

Further, adding LED lamps around the escape opening significantly negated this effect. For the other by-catch species of fish, results indicated similar trends but were not statistically significant.

THE SECOND STUDY: GREEN LED LAMPS ON THE LOWER PART OF THE NORDMØRE GRID



In the second study we used the standard Nordmøre grid section with 0.5 m between the guiding panel and the grid surface. We attached 4 green LED lamps in the lower part of the Nordmøre grid.

Study II: We investigated and compared the selective properties for Deep-water shrimps and four bycatch species of fish in:

- A standard Nordmøre grid section.
- A standard Nordmøre grid section with LED lamps.

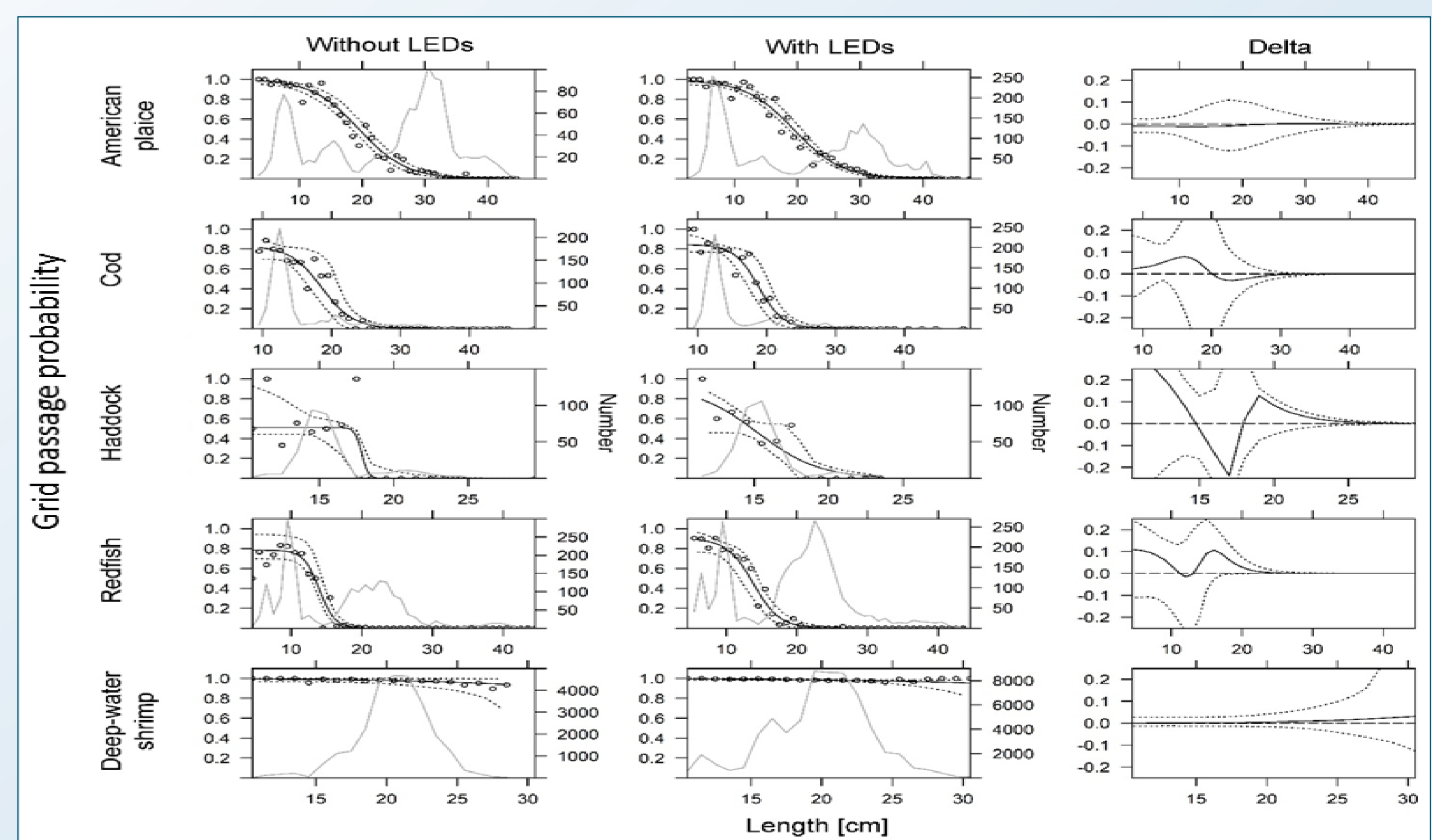
Model for size selection:

The size dependent probability $p(l)$ of a shrimp or fish passing through the Nordmøre grid and entering the codend:

$$p(l, C_{grid}, L50_{grid}, SR_{grid}) = \frac{C_{grid}}{1.0 + \exp\left(\frac{\ln(9)}{SR_{grid}} \times (l - L50_{grid})\right)}$$

The difference in grid passage probability (p) between the two Nordmøre grid configurations is expressed with the function delta; $\Delta p(l)$:

$$\Delta p(l) = p_{LED}(l) - p_{Base}(l)$$



Dots illustrate experimental rates, solid curves represent the fitted model, and the dashed curves are the 95% confidence bands for the curves.

RESULTS AND CONCLUSION

Adding LED lamps, we found for the four bycatch species of fish investigated that 50-99% of small fish passed through the Nordmøre grid.

The addition of green LEDs to the Nordmøre grid did not significantly affect the escape probability and the size selectivity of any of the investigated species.

Very few Deep-water shrimps were found to escape through the escape opening independent of the presence of the green LED lamps mounted on the grid.

We thank the crew of RV "Helmer Hanssen", technicians and students for valuable assistance on board. We are also grateful to the Arctic University of Norway (UiT) in Tromsø, the Norwegian Directorate of Fisheries and the Norwegian Seafood Research Fund (project no. 901303) for funding the experiments.