

# **Further experiments with LED-lights along the fishing line to reduce the by-catch of juvenile fish in the Norwegian shrimp trawl fishery**

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## **Abstract**

This is the third cruise investigating the effect of Led-lights along the fishing line in Norwegian shrimp trawls fisheries. The setup was equal to the two previous cruises (Larsen, 2015; Brinkhof and Larsen, 2015), and based on the initial idea from Hannah et al., 2015, reporting promising results of reducing unwanted by-catch of fish and fish fry in shrimp trawls. A total of 16 valid hauls were obtained during the cruise, in an alternate haul setup. The trials were made in two different shrimp fishing grounds, Grøtsundet and Lyngenfjorden, during 7.-11. December, i.e. a period with no sun light available. In the experimental setup a total of 30 Led-lights were spread along the fishing line. Due to the large variation between the hauls the results should be interpreted with caution, i.e. the results provide no basis for any solid inference. The results could indicate a tendency for the hauls with Led-lights with a reduction in the amount of by-catch as well as loss of shrimp, however, the variability between the hauls was too large, providing no basis for any solid inference.

## **Introduction**

Decades of research, especially in Norway, has led to considerable improvement in the selective properties of shrimp trawls. The rigid Nordmøre grid, designed in 1989, has by far been the most important contribution to a selective shrimp trawl fishery, worldwide. The Nordmøre grid with 19 mm bar spacing has been compulsory in the Norwegian inshore shrimp trawl fishery for deep-water shrimp (*Pandalus borealis*) since 1990, and since 1993 in the deep sea shrimp trawl fishery. Despite of reducing the by-catch of fish more than 95 % (by weight) with a minimal loss of shrimp catch (0.5-4.0 %), is the exclusion of fish below 15-20 cm unsatisfactory (Isaksen and Larsen, 1991; Isaksen et al., 1992; Larsen and Isaksen, 1993; Grimaldo and Larsen, 2005). According to the current regulations for the northern shrimp fishery, enforced by the Norwegian Directorate of Fisheries, the amount of fish per 10 kg of shrimp is not allowed to exceed 8 cod (*Gadus morhua*), 20 haddock (*Melanogrammus aeglefinus*), 3 redfish (*Sebastes* spp.), and 3 Greenland halibut (*Reinhardtius hippoglossoides*) (Directorate of Fisheries, 2011). In case the shrimp catches exceed one of these limits, the fishing ground is closed for shrimp trawling. Hence, many of the northern shrimp grounds are closed annually, for extended periods. Any reduction in the catch of fish and fish fry not selected out by the Nordmøre grid would thus be an improvement for the fishery, due to stable access to the fishing ground and reduced labor in sorting out fish from the shrimp catch, as well as for the management of the fisheries.

In 2014, Hannah et al., (2015) presented promising results of reducing by-catch of fish in the Oregon shrimp trawl fishery, using green Electralume LED lights attached with equal distance along the fishing line. Due to the above described situation in the Norwegian shrimp trawl fishery these encouraging results were of high interest. After the two previous conducted in February 2015 (Larsen, 2015) and May 2015 (Brinkhof and Larsen, 2015), investigating the effect of Led-lights attached to the fishing line in the Norwegian shrimp trawl fishery, using a similar setup as used by Hannah et al., (2015), a third cruise was conducted in December, 2015.

## **Materials and methods**

The cruise was conducted onboard the R/V “Johan Ruud” (30.5 m, 1000 HP), from 7<sup>th</sup> to 11<sup>th</sup> of December 2015, on to different shrimp fishing grounds. The first day was conducted at a shrimp fishing ground north of Tromsø, Grøtsundet (N 69°78' - 69°79' and E 19°24' - 19°32'), while the two other days were conducted in Lyngenfjord (N 69°37' - 69°40' and 20°22' - 20°26'). The trawl setup consisted of a pair of Thyborøn otter boards, connected to 40 m long bridles, followed by a rock-hopper gear. The rock-hopper gear consisted of 10" discs with a distance between of 30 cm in the center section and 60 cm distance in both side sections (a rock-hopper gear with 14" discs was used during the two previous cruises). The rock-hopper was attached to the 52 m long fishing line with ca. 30 cm long toggles. The trawl is a standard coastal shrimp trawl, 1300 meshes in circumference. For the test hauls a total of 30 green Electralume Led lights were attached to the fishing line covering the entire length of the fishing line. The distance between the lights was 1.3 m in the center section of the fishing line (24. 7 m), and 2.5 m in both side sections of the fishing line (12.5 m). Thus, 10 more lights were attached to the fishing line during this cruise, compared to the two previous cruises. In order to sample the data in pairs, alternate haul setup was applied. The experiments were conducted with towing speed of ca. 2.2 knots at a depth of 165-185 m in Grøtsundet, and 240-260 m in Lyngen. All hauls were conducted during daytime at a time of year with no ambient sun light available, only twilight a few hours at midday. In order to obtain an overview over the size distribution of the fish in the area a small meshed cover was used for a few hauls. (The reason for not using a cover throughout the test period is two-folded; too much fish and possible negative effect on the selective performance of the NM grid).

The data were analyzed by comparing the catch for the hauls conducted with the Led-lights attached to the fishing line (test) with the hauls conducted without lights attached to the fishing line (control). The graphical presentations are conducted in R (R Core Team, 2013).

## **Results**

A total of 17 hauls were conducted during the cruise, whereof one haul was labeled invalid due to clay aggregation in front of the grid. The first 4 hauls (2 pairs) were conducted in Grøtsundet, while the other 12 hauls (6 pairs) were conducted in Lyngenfjord. On both locations two hauls (one pair) were conducted with cover for retaining escaping fish (as a result of the Nordmøre grid).

Comparing the pooled catch from the first area (Grøtsundet), resulted in a considerable reduction in the by-catch of haddock, American plaice and Lemon sole (by numbers), and of Norway pout and Silvery pout (by weight), between the two hauls conducted with Led-light

with the two hauls conducted without using light (Table 1). The catches of cod were equal for both setups. However, the comparison is based on few hauls, with few fish, especially for the two gadoid species. Additionally, the shrimp loss for the hauls conducted with light is severely high.

**Table 1.** The pooled catch (in terms of numbers of fish) retained in the codend for the hauls conducted with and without lights attached to the fishing line for the hauls conducted in Grøtsundet.

Species	Catch with LED-lights	Catch without LED-lights	Reduction in bycatch (%)
Cod ( <i>Gadus morhua</i> )	4 (n)	4 (n)	0.00
Haddock ( <i>Melanogrammus aeglefinus</i> )	1 (n)	4 (n)	75.00
American plaice ( <i>Hippoglossoides platessoides</i> )	38 (n)	58 (n)	34.48
Lemon sole ( <i>Microstomus kitt</i> )	29 (n)	42 (n)	30.95
Norway pout ( <i>Trisopterus esmarkii</i> )	50.3 (kg)	80.5 (kg)	37.52
Silvery pout ( <i>Gadiculus argenteus</i> )	6.7 (kg)	8.9 (kg)	24.72
Shrimp ( <i>Pandalus borealis</i> )	23.6 (kg)	46 (kg)	48.70

Comparing the pooled catch by weight for the hauls conducted with (6 hauls) and without (6 hauls) Led-lights attached to the fishing line in Lyngenfjord, also resulted in a considerable reduction in the shrimp catch (Table 2.). However the reduction in the by-catch of cod juveniles is encouraging (Table 2). The catch by weight for American plaice increased for the hauls conducted with Led-lights (Table 2), however, the same comparison in terms of number of fish caught resulted in a slight reduction in the by-catch of the species (Table 3). In terms of number of fish the by-catch of cod was reduced considerable, while the catches of Lemon sole were nearly doubled for the hauls conducted with Led-lights.

**Table 2.** The pooled catch (in weight) retained in the codend for the hauls conducted with and without lights attached to the fishing line for the hauls conducted in Lyngenfjord.

Species	Catch with LED-lights (kg)	Catch without LED-lights (kg)	Reduction in catch (%)	Increased catch (%)
Shrimp ( <i>Pandalus borealis</i> )	39.95	54.86	27.18	-
Cod ( <i>Gadus morhua</i> )	4.29	6.28	31.69	-
American plaice ( <i>Hippoglossoides platessoides</i> )	3.3	2.59	-	21.52

**Table 3.** The pooled catch (in terms of numbers of fish) retained in the codend for the hauls conducted with and without lights attached to the fishing line for the hauls conducted in Lyngenfjord.

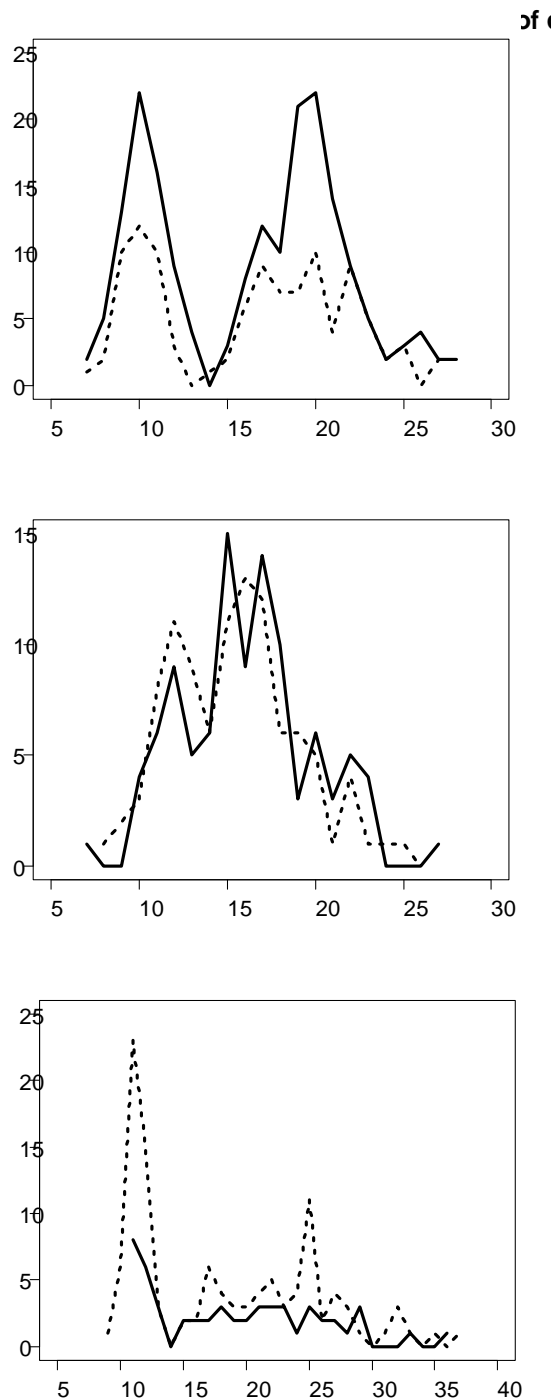
Species	Number of fish with LED-lights	Number of fish without LED-lights	Reduction in bycatch (%)	Increased by-catch (%)
Cod ( <i>Gadus morhua</i> )	94	184	48.91	-
American plaice ( <i>Hippoglossoides platessoides</i> )	100	102	1.96	-
Lemon sole ( <i>Microstomus kitt</i> )	112	60	-	46.43

Comparing the hauls conducted in pairs (after each other) demonstrates a large variability in the catch from haul to haul, with subsequent large variability in the percentage of by-catch reduction (Table 4). For instance the improved by-catch and shrimp catch when comparing haul 5 and 6 is believed to be caused due to a sudden shift in population encountered in the area or some factors influencing trawling efficiency and is most likely not an effect provoked by the Led-lights attached to the fishing line. The increase in the by-catch of Lemon sole presented in Table 3 is mainly caused by the sudden increase in haul number 13 and 14 (Table 4). Additionally, since the (by-) catches are small, a small variation in the catch amount will cause in a significant impact on the results.

**Table 4.** Catch in paired hauls with and without lights attached to the fishing line. The shrimp catch is presented in weight, the fish species are presented in numbers of individuals. Haul 1-4 was conducted in Grøtsundet, while haul 5-17 was conducted in Lyngenfjord.

<b>Species/Haul</b>	<b>Catch without light</b>	<b>Catch with light</b>	<b>Reduction (%)</b>	<b>Increase (%)</b>
<b>Haul 1 &amp; 2, Grøtsundet</b>				
Shrimp (kg)	40.5	8.6	78.77	-
Cod (n)	3	2	33.33	-
Haddock (n)	3	1	66.67	-
American plaice (n)	31	23	25.81	-
Lemon sole (n)	16	14	12.50	-
<b>Haul 3 &amp; 4, Grøtsundet</b>				
Shrimp (kg)	5.5	15	-	63.33
Cod (n)	1	2	-	50
Haddock (n)	1	0	100.00	-
American plaice (n)	27	15	44.44	-
Lemon sole (n)	26	15	42.31	-
<b>Haul 5 &amp; 7, Lyngenfjord</b>				
Shrimp (kg)	20.4	6.5	68.14	-
Cod (n)	38	20	47.37	-
American plaice (n)	22	6	72.73	-
Lemon sole (n)	23	10	56.52	-
<b>Haul 8 &amp; 9, Lyngenfjord</b>				
Shrimp (kg)	2	2.9	-	31.03
Cod (n)	10	9	10.00	-
American plaice (n)	11	6	45.45	-
Lemon sole (n)	2	7	-	71.43
<b>Haul 10 &amp; 11, Lyngenfjord</b>				
Shrimp (kg)	3.7	2.2	40.54	-
Cod (n)	29	28	3.45	-
American plaice (n)	13	10	23.08	-
Lemon sole (n)	1	5	-	80
<b>Haul 12 &amp; 13, Lyngenfjord</b>				
Shrimp (kg)	18.8	15.7	16.49	-
Cod (n)	53	19	64.15	-
American plaice (n)	16	19	-	15.79
Lemon sole (n)	14	36	-	61.11
<b>Haul 14 &amp; 15, Lyngenfjord</b>				
Shrimp (kg)	5	10.2	-	50.98
Cod (n)	21	9	57.14	-
American plaice (n)	12	42	-	71.43
Lemon sole (n)	8	28	-	71.43
<b>Haul 16 &amp; 17, Lyngenfjord</b>				
Shrimp (kg)	4.9	2.45	50.00	-
Cod (n)	33	9	72.73	-
American plaice (n)	28	17	39.29	-
Lemon sole (n)	12	26	-	53.85

Figure 1 presents the length distribution for the three by-catch species caught in Lyngenfjord. The distribution show no trends between the hauls conducted with led-lights (stippled line) and the hauls conducted without led-lights (solid line). The two hauls with a sudden increase in the catch of Lemon sole are clearly seen as the two peaks in the length distribution.



**Figure 1.** Length distribution for the different fish species caught in Lyngenfjord, cod, American plaice, and Lemon sole, for the hauls conducted without light (solid line), and for the hauls conducted with lights attached to the fishing line (stippled line).

## **Discussion and conclusion**

Based on the results presented in the section over, it is believed that no solid inference could be taken, due to the large variation in the amount of catch between the hauls as well as within haul-pairs (Table 4). This between haul variations is likely to be caused due to factors influencing the catchability of the trawl as well as fish/shrimp behavior, such as water current and diurnal migration and grid clogging. Compared to the results from the two previous cruises presented in Larsen (2015), and Brinkhof and Larsen (2015), the current results are even more inconclusive. For both previous cruises the comparison of the hauls conducted without led-lights with the hauls conducted using led-lights revealed a tendency of the latter having less by-catch of especially cod, haddock, American plaice, and Lemon sole. The loss of shrimp was, like the present result, too high. However, like the present results, the between haul variation was large. For example, although there is a considerable shrimp loss for the hauls conducted with led-lights when summarizing the catch, the haul to haul comparison in Table 3 shows that the shrimp catch was increased several times when using led-lights.

Thus, the overall results indicate that led-lights along the fishing line could possibly reduce the by-catch of especially for the two gadoid species, cod and haddock and the two flounder species American plaice and Lemon sole. In the meantime, the loss of shrimp is high, however the between haul variation is considerable larger for the shrimp catches than for the catches of fish. A better research design, using double trawl, would mitigate the effect of between haul variability, resulting in more conclusive results.

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