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ARTICLE

Application of Luminescent Netting in Traps to Improve the Catchability of the Snow Crab *Chionoecetes opilio*

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Abstract

In this study, we investigated luminescent netting as a means to improve the catch rates of snow crabs *Chionoecetes opilio*. A laboratory experiment was conducted to investigate the intensity and duration of luminescence using time-lapse photography. We exposed experimental traps to five different treatments of UV light to excite the luminescent fibers in the netting. Our results showed that luminescent netting can be effectively activated to emit light, and that the resulting intensity and duration of luminescence emitted over time depends on the initial duration of UV exposure and the source of light. A fishing experiment was subsequently conducted in eastern Canada to compare the catch rate of traditional and luminescent traps, and to determine how soak time affected catch rate. Results indicate that the effect of luminescent traps on the CPUE (measured as number of crab per trap) depended on the soak time. The CPUE was significantly higher (a 55% increase) in luminescent traps that underwent relatively short soak times (~1 d), but when soak times were longer (~8 d), the CPUE was not significantly different.

For more than five decades, the snow crab *Chionoecetes opilio* fishery has provided a significant source of income for coastal communities in Canada's most eastern province, Newfoundland and Labrador (Davis 2015). In 2017, approximately 33,584 metric tons of snow crab were landed, corresponding to Can$325 million, representing the

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highest landed value of marine product in the province (DFA 2017). However, the resource has shown signs of decline in recent years, resulting in a reduction in the total allowable catch and dockside landings over the past 10 years. The overall quota decreased by 43% from 51,582 metric tons in 2014 to only 29,390 metric tons in 2018 (DFO 2014, 2018). Additional challenges facing the snow crab fishery include (1) reduced abundance levels due to environmental change and disease (Marcogliese 2008; Wassmann et al. 2011; Mullowney et al. 2014); (2) interaction with mobile shrimp trawling (Nguyen et al. 2014); (3) effects of underwater noise from seismic exploration (Morris et al. 2018); (4) potential interaction with marine mammals (Benjamins et al. 2012); (5) suspension of marine stewardship council certification; and (6) increases in operating cost (Davis 2015).

In response to these challenges, improvements in fishing efficiency through increased catch rates and reduced operating costs (e.g., less bait, fuel, and labor) are currently being considered as methods to maintain the economic viability of fishing enterprises. To date, several studies have been undertaken to improve the catchability and selectivity of traps that target snow crabs, including modifications of the trap's shape (Cyr and Sainte-Marie 1995; Hébert et al. 2001; Sainte-Marie and Turcotte 2015), bait type and amount (Cyr and Sainte-Marie 1995; Grant and Hiscock 2009; Araya-Schmidt et al. 2019), escape mechanisms (Winger and Walsh 2007, 2011), and underwater lights (Nguyen et al. 2017; Nguyen and Winger, in press). As a commercially important species, strict regulations are enforced to maintain a sustainable fishery, including input controls (e.g., fishing capacity, vessel usage, and fishing effort), output controls (e.g., total allowable catch), technical measures (e.g., trap characteristics and minimum landing size; DFO 2017), and a new regulation to reduce the amount of floating rope on the water's surface to reduce negative encounters with North Atlantic right whales *Eubalaena glaciali* (DFO 2018).

Previous studies have shown that snow crabs exhibit positive responses to artificial light, resulting in increased catch rates when baited traps are equipped with low-powered LED lights (Nguyen et al. 2017; Nguyen and Winger, in press). In at least one case, the economic performance of using LED lights in traps has been evaluated, with an estimated profit of up to $1,100 per metric ton of quota per fishing vessel annually (Nguyen and Winger 2018). However, the use of LED lights in baited traps are not without their challenges. Investing in LED lights requires initial capital costs and the regular replacement of batteries during the lifetime of the lights. Economic profit depends on a variety of factors, such as input costs (e.g., fuel, bait, and labor), output value (e.g., crab price), and the amount of quota allocated, making it difficult to confidently predict the period of time until fishing enterprises achieve a return on investment (Nguyen and Winger 2018). Finally, purchasing and equipping every trap with an LED light is certain to produce ecological costs. Possible negative effects include increased marine litter and CO_2 emissions associated with the production of plastics (Nguyen and Winger 2019).

A potential alternative to LED lights is luminescent netting. Euronete Company (Maia, Portugal) recently introduced a novel polyethylene netting (EuroGlow) containing luminescent fibers. The fibers absorb UV radiation when exposed to sunlight, exciting the particles, which then emit light. A trap constructed using the luminescent netting costs $10 more than a traditional trap ($64 versus $54), but this investment is more economical than installing an LED light, which costs approximately $60 and requires the ongoing replacement of batteries. However, no scientific literature is available to document the engineering and fishing performance of luminescent traps. The purpose of this study was to address this knowledge gap. We investigated the potential application of luminescent netting for the snow crab fishery in the Province of Newfoundland and Labrador. We conducted a laboratory experiment to investigate the intensity and duration of luminescence using time-lapsed photography, followed by a fishing experiment to compare the catch rate of traditional and luminescent traps and how they are affected by different soak times. Our results were compared with the results from other recent research using LED lights, and the possible application of this method to commercial fishing operations is discussed.

METHODS

Laboratory experiment.— This experiment was conducted at the Memorial University of Newfoundland Fisheries and Marine Institute in 2018 between April and August. A small experimental room ($8\,m^3$) was built to hold a luminescent trap. Black plastic sheets were used to cover all sides of the room, preventing light from entering or exiting. Photos were taken by a Canon EOS Rebel T5i DSLR camera, and were used to capture the light intensity of the trap. The trap was placed 0.5 m away from the camera, which was equipped with a Canon EF-S 18–55 mm 1:3.5 lens. The camera was programmed using Canon's EOS Utility software (version 28.0). For measurements at low-light intensities, the camera was set to the highest ISO of 1600, the shutter speed was set to 15 s, and the focus was set to manual. The EOS Utility software was used to program the camera to take one picture every 10 min for at least 6 h.

Ultraviolet lights (ADJ Group; UV Flood 36) were mounted inside the room to “charge” the experimental traps. A total of four lighting units were used, each containing 12 individual 3-W diodes ($4 \times 12 \times 3 = 144$ W total). The wavelength of the UV light varied between 395 and 400 nm, according to manufacturer specifications. Each lighting unit had dimensions of 300 mm long × 235 mm wide × 115 mm high, with a weight of 2.2 kg. The UV lights were suspended near the ceiling of the room, orientated toward the trap, and spaced between 0.8 and 1.2 m away from the trap. See Figure 1 for a schematic drawing of the experimental setup.

Traps were exposed to the artificial UV light for either 1 s, 1 min, 5 min, or 10 min, and then photographed in the dark for 6 h to document the change in light intensity over time. In between trials, the trap was left covered in the dark for at least 12 h to ensure that no residual light from the previous trials remained. A fifth experimental treatment was undertaken using natural sunlight. The weather on experimental days was sunny with scattered clouds and a high UV index of ≥6. The trap was placed in direct sunlight for 10 min, and then immediately returned to the experimental room to begin the photographing process. Figure 2 shows the experimental trap following charging. Eight replicates were conducted for each treatment. Baseline photos (e.g., the experimental room with no trap and no UV light) were also taken in order to identify the baseline level of illumination in the room. A total of 1,680 photos were successfully taken and analyzed during the experiment (1,600 experimental photos and 80 baseline photos).

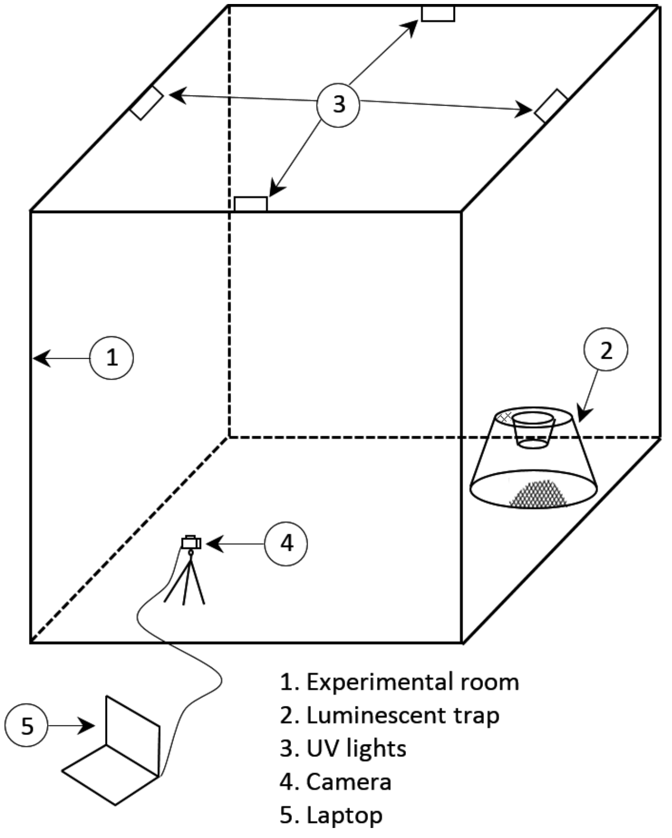

FIGURE 1. A schematic drawing of the laboratory setup for filming traps in the dark.

In order to quantify the light intensity within each photo, the electronic images were loaded into open source ImageJ software, which was developed by the National Institutes of Health and the University of Wisconsin (version 1.8.0_112; available at https://imagej.nih.gov/ij/download.html). Images were analyzed for their "mean gray value," which is commonly used to evaluate light intensity (Selinummi et al. 2005; Collins 2007; Vrekoussis et al. 2009; Ristivojević et al. 2017). The mean gray value in an image is considered a measurement of the light intensity within the image, based on the red, green, blue (RGB) model (Hunt 2004). The mean gray value is the sum of the gray values of all the pixels divided by the number of pixels. For RGB images, the mean is calculated by converting each pixel to grayscale using the following formula (Hunt 2004; Seletchi and Duliu 2007):

$$\text{gray} = (0.299 \cdot \text{red}) + (0.587 \cdot \text{green}) + (0.114 \cdot \text{blue}).$$

Using ImageJ software, the mean gray value of each image was obtained by selecting "gray value" and "set measurements" with regards to the area.

Fishing experiment.— A comparative fishing experiment was undertaken in 2018 between April and June on the south coast of Newfoundland during the annual commercial fishery. The depth at the sampling sites ranged from 140 to 155 m for the inshore area, and from 170 and 182 m for the offshore area. Experimental and control (i.e., traditional) traps were deployed from three different snow crab vessels in both inshore and offshore areas (Table 1; Figure 3). A total of 20

FIGURE 2. A photograph of an experimental luminescent trap in the dark.

TABLE 1. A summary of the details for the comparative fishing experiment using snow crab traps. Exp = experimental traps; Ctr = control (traditional) traps.

Vessel name	Vessel length (m)	Location	Fishing site	Fleet deployment	Exp	Ctr
F/V *Trusty*	12.0	Harbour Breton	Inshore	4	20	20
F/V *Paula Charlene*	11.9	Hermitage	Inshore	2	20	20
F/V *Another Girl*	10.4	Harbour Breton	Offshore	2	20	20

experimental traps and 20 control traps were used per vessel. All of the traps were new and identical, except that the experimental traps had luminescent fibers woven into their netting. A summary of experimental information is shown in Table 1. Each trap contained 1.36 kg of bait, consisting of a combination of frozen Atlantic Herring *Clupea harengus* and northern shortfin squid *Illex illecebrosus*.

Traps were deployed after sunrise between 0710 and 1100 hours, allowing sufficient exposure to UV radiation from the sun during the daytime on the deck. The weather on fishing days was sunny with a UV index of greater than 7. We assumed that luminescent traps were fully charged during the steaming period. Both trap types (experimental and control) were randomly located within a fleet for comparative purposes. Each fleet consisted of 20 traps. Each trap was spaced at intervals of 45 m along the fleet. A total of eight fleets of gear were deployed and retrieved during the course of study. Fishing practices were similar to the traditional fishing habits of the snow crab fishery. The traps were soaked for 1 d (~24 h) in the inshore sampling sites and for 8 d in the offshore sampling sites (~191 h). The number of crabs was counted from each retrieved trap and reported as CPUE (measured as number of crab per trap) for legal- versus sublegal-sized crab, which was determined by the crew. For short soak times, we randomly selected a few traps to compare the size selectivity between experimental and control traps. Traps were randomly selected from each treatment (luminescent and control traps) and from each fleet to measure the carapace width (CW) of all crabs in that trap using Vernier calipers to the nearest mm. Legal-sized crabs (CW of ≥ 95 mm) were retained for commercial purposes, and sublegal-sized crabs (CW of < 95 mm) were immediately returned alive to the ocean after sampling. Offshore fishing practices precluded our ability to get additional detailed measurements beyond distinguishing between legal and sublegal size.

Statistical analysis.— For the laboratory experiment, the relationship between mean gray value (i.e., light intensity) and time decreased exponentially, and the data was fit with a log-linear model:

$$y(t) = Ce^{kt}, \tag{1}$$

where y is light intensity at time t. The variables C and k are constants, and obtained from the model; k is usually a negative value because light intensity decreases with time.

For the fishing experiment, a generalized linear mixed-effect model (GLMM) was used to estimate the effect of trap treatment on the CPUE of snow crabs. Since the CPUE is count data, it was best modeled with a negative binomial distribution (Jørgensen et al. 2017; Bergshoeff et al. 2018; Meintzer et al. 2018; Nguyen and Winger, in press). Analyses were conducted separately for each soak

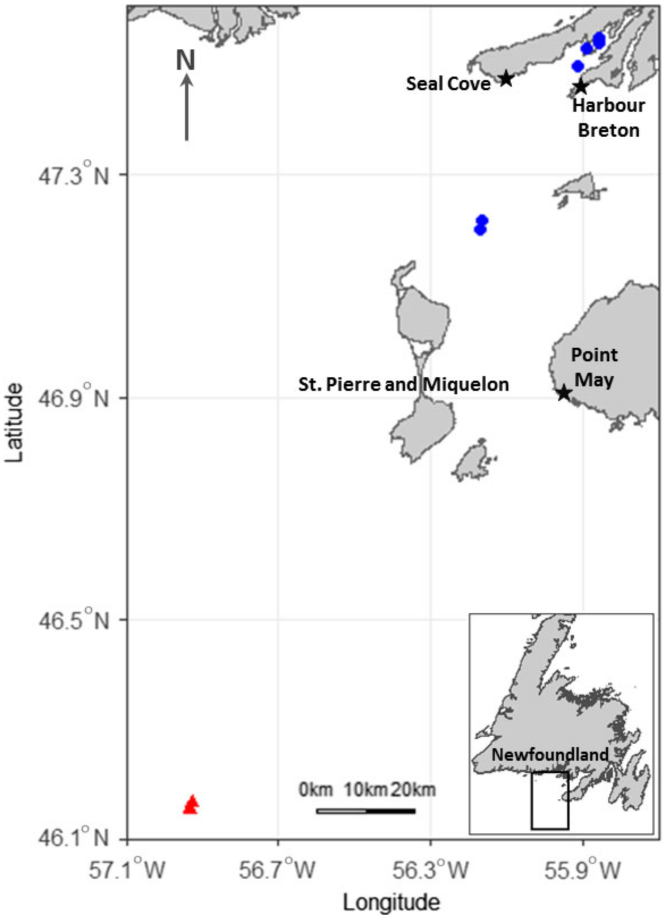

FIGURE 3. The location of sampling sites off the south coast of Newfoundland. The rectangle on the bottom-right of the figure indicates the sampling area. Each blue dot indicates the location of a short-soaked, inshore, individual fleet of traps that was deployed during the study, while the red triangles represent long-soaked, offshore sampling.

time condition via the glmmadmb function based on the glmmADMB package in R statistical software (R Core Team, Vienna). All assumptions of the GLMM were met with regard to homogeneity of variance, normal distribution of errors, and independence of errors. We fit the following model:

$$\log(y) = \log(\text{soak time}) + \alpha + \beta_1\text{treatment} + b + \varepsilon,$$

where y is the log of CPUE, the log of soak time is an offset, α is the intercept, $\beta_1$treatment is the trap treatment, b is the random variable representing the variability among fleets nested within the vessel (where $b \sim N[0, \sigma^2]$), and ε is the error term with a negative binomial distribution.

The carapace width length between luminescent and control traps was compared for short soak times. The catch proportion between each treatment was compared with a GLMM using the glmmPQL function from the MASS package following the methods of Holst and Revill (2009).

We fit the following model:

$$\text{logit}(y) = \log(q_e/q_c) + \alpha + \beta_3 + \beta_2 + \beta_1 + b + \varepsilon,$$

where y was the logit of catch proportion between traps ([exp/{exp + ctr}], where exp is the luminescent trap and ctr is the control trap). The log of the subsample was an offset, where (q_e/q_c) was the subsample ratio between e (luminescent trap) and c (control trap). The intercept was α, β_3 through β_1 was the modeled polynomial (i.e., cubic, quadratic, and linear) coefficients, b the random variable representing the variability among fleets (where $b \sim N[0, \sigma^2]$), and ε is the error term with a binomial distribution. For further details, see Holst and Revill (2009). We began by using higher-order polynomials (i.e., cubic, quadratic, linear, or constant) to fit the proportions at each length class retained in the experimental traps to those retained by experimental traps and control traps, followed by subsequent reductions until all terms showed significance ($P < 0.05$), with removal of one term at each step to determine the best-fit model (Holst and Revill 2009).

RESULTS

Laboratory Experiment

Measures of raw light intensity of the luminescent trap with different treatments ranged between 1.52 and 60.30 pixels, while the baseline raw light intensity (empty experimental room) was 0.28 pixels. Therefore, the trap maintained a low light intensity after 6 h, which varied around 1.52 pixels for all charge treatments. The relationship between light intensity and time postcharge for the different charging treatments is shown in Figure 4. The variability of light intensity between the time series and within the treatment was low, thus the 95% CI along the regression lines were narrow (Figure 4).

The charging time significantly affected the light intensity and duration of luminescence; traps exposed to UV light for longer periods produced a higher intensity. The initial modeled light intensity (i.e., the C value of the model) for the 1 s, 1 min, 5 min, and 10 min treatments were 21.777, 33.613, 37.421, and 49.446 pixels, respectively (Table 2; Figure 4). Each UV treatment resulted in similarly shaped, decreasing, exponential curves that converged toward zero light intensity at approximately 100 min for each treatment. Based on an evaluation of the confidence intervals, the light intensity of the 1 s treatment was significantly lower than all other treatments until they converge at 100 min. The intermediate treatments (1 and 5 min), had very similar values of light intensity throughout the experiment, but the 5 min treatment had a slightly larger initial charge. The 10 min treatment was higher throughout the first 100 min.

The sunlight treatment had a less severe, decreasing relationship over time. The initial light intensity level was the lowest of all treatments. At the 25 min duration, the intensity level was equivalent to the intermediate treatments (1 and 5 min); at 48 min, the intensity was equivalent to the longest treatment (10 min); and at 215 min, the intensity reached zero, having the longest duration of all treatments. This relationship was explained in the model by having the lowest initial intensity ($C = 18.995$) and the longest duration due to the highest k value (Table 2).

Fishing Experiment

The results from the fishing experiment indicated that the effect of the luminescent trap on the CPUE of legal-sized crabs was dependent on the soak time. The model output predicted that the luminescent trap resulted in a 55% higher catch rate of legal-sized crabs than the control traps ($P = 0.001$) with shorter soak times (Table 3). At longer soak times, the catch rate of legal-sized crabs was not significantly different ($P = 0.61$; Table 4). The modeled catch rate for the short soak times for legal-sized crabs was 6.5 CPUE for the experimental trap and 4.2 CPUE for the control trap (Table 3). For longer soak times, the catch rate of legal-sized crabs was 25.8 CPUE for the experimental trap and 26.8 CPUE for the control (Table 3). There were no statistically significant differences in the CPUE of sublegal-sized crabs between the experimental and control traps for both short and long soak time deployments ($P > 0.05$) (Table 3; Table 4). The modeled catch rate of sublegal-sized crabs was 1.12 CPUE and 1.13 CPUE for the luminescent and control traps for the short soak time, respectively (Table 3). The modeled catch rate of sublegal-sized crabs was 1.50 CPUE and 1.30 CPUE for the luminescent and control traps for the long

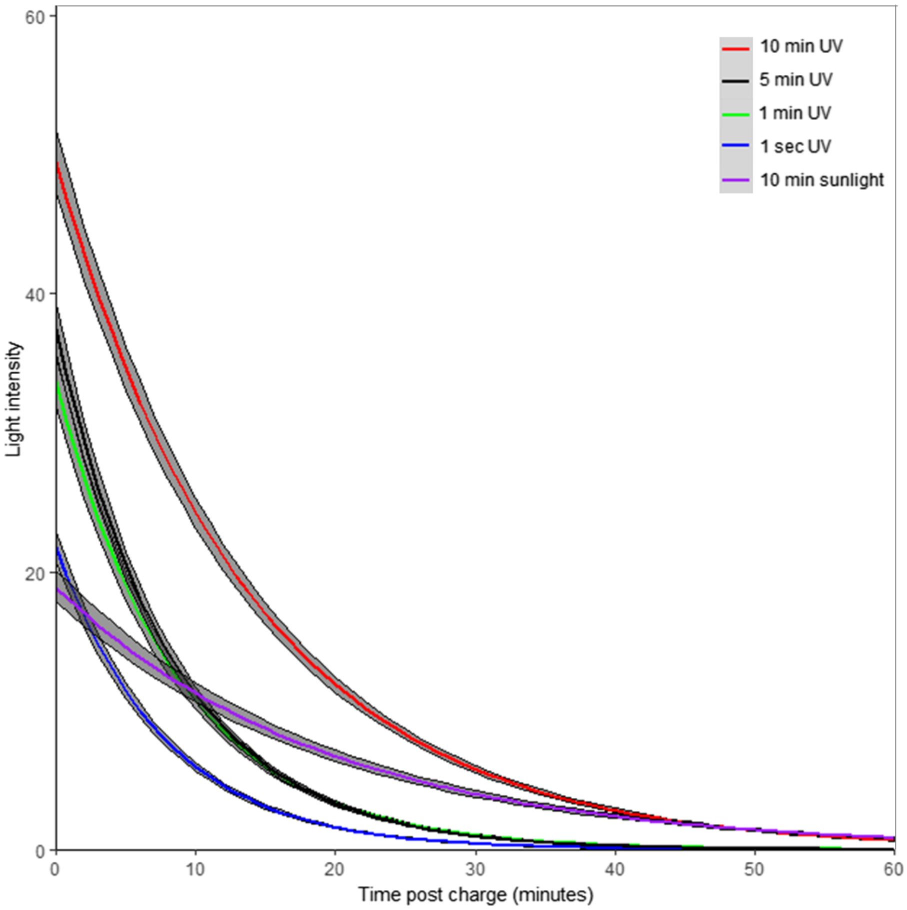

FIGURE 4. The modeled relationship between light intensity (pixels; mean gray value) and time postcharge for the different charge treatments. The shaded areas represent the 95% CI.

TABLE 2. Parameters of a log-linear model for different treatments of snow crab traps with luminescent netting. *C* and *k* are the constants represented in equation (1). SE is the standard error of the estimate.

Treatment	*C*	*k*	SE	*t*-value	*P*-value	R^2
1 s UV	21.777	−0.129	0.555	39.22	<0.001	0.977
1 min UV	33.631	−0.115	0.926	36.32	<0.001	0.944
5 min UV	37.421	−0.121	0.930	40.24	<0.001	0.960
10 min UV	49.446	−0.072	1.145	43.19	<0.001	0.936
10 min sunlight	18.955	−0.052	0.5786	32.76	<0.001	0.955

soak time, respectively (Table 4). Figure 5 illustrates the proportion of crabs captured using the experimental and control traps for each soak time.

The carapace width of crabs captured in short-term-soaked traps ranged from 51 to 140 mm for the different treatments (range = 51–135 mm for control traps and 64–140 mm for experimental traps; Figure 6A). A GLMM model with a logit-constant curve (zero degree polynomial) best fit the proportion of crabs at each length class ($\beta_0 = 0.41$, SE = 0.2, $t = 2.04$, df = 117, $P = 0.04$; Figure 6B). The results indicated that larger crabs were captured by the luminescent traps; however, these differences were not significant due to a 0.5 overlap in the CI. In essence, there was no difference in size-based selectivity between the luminescent traps and control traps for short soak times.

DISCUSSION

Our results showed that luminescent netting can be effectively activated to emit light, and that the resulting

TABLE 3. The GLMM estimated regression parameters of snow crab catch comparison for short soak times.

Fixed effects	Estimate	SE	*z*-value	95% CI	*P*-value	Variance	SD
Legal-sized crab							
Intercept	1.43	0.29	5.01	1.39–2.30	<0.001		
Trap treatment	0.44	0.13	3.28	0.19–1.01	0.001		
Random factor							
FleetID						0.42	0.65
Vessel						<0.001	0.01
Sublegal-sized crab							
Intercept	0.12	1.27	0.09	0.09–2.57	0.93		
Trap treatment	–0.01	0.22	–0.05	–0.35 to 0.51	0.96		
Random factor							
FleetID						1.45	1.2
Vessel						2.48	1.57

intensity and duration of luminescence emitted depends on the initial duration of UV exposure and the source of light. Assuming that the traps used in our fishing experiment performed similarly to those in the laboratory, we would have expected the visibility of the traps to decay rapidly. Thus, we speculate that the emissions from the luminescent netting were likely too low to elicit an increased ingress rate of snow crabs into the traps after the first initial hours. Our CPUE data appear to corroborate this hypothesis, given that significant differences were only detected during the shorter soak times at the inshore fishing locations. This suggests that the positive benefits of luminescent netting decrease with increasing soak time, and at some point the trap will function similarly to a traditional trap, relying solely on attraction by bait. The opposite has been shown for low-powered LED lights. Nguyen et al. (2017) and Nguyen and Winger (in press) both reported that longer soak times disproportionately

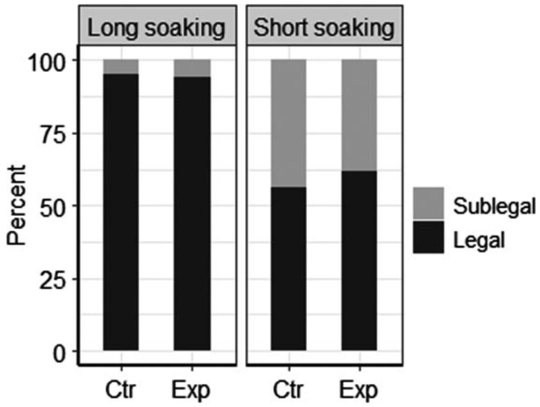

FIGURE 5. The proportion of legal and sublegal-sized crab captured by the control (ctr) and experimental (exp) traps at different soaking levels.

TABLE 4. The GLMM estimated regression parameters of snow crab catch comparison for long soak times.

Fixed effects	Estimate	SE	*z*-value	95% CI	*P*-value	Variance	SD
Legal-sized crab							
Intercept	3.29	0.10	32.24	1.96–3.75	<0.001		
Trap treatment	–0.04	0.08	–0.51	–0.18 to 0.12	0.61		
Random factor							
FleetID						0.02	0.12
Vessel						<0.001	0.01
Sublegal-sized crab							
Intercept	0.26	0.20	1.34	0.88–1.91	0.18		
Trap treatment	0.14	0.27	0.53	0.68–1.95	0.59		
Random factor							
FleetID						<0.001	<0.001
Vessel						<0.001	<0.001

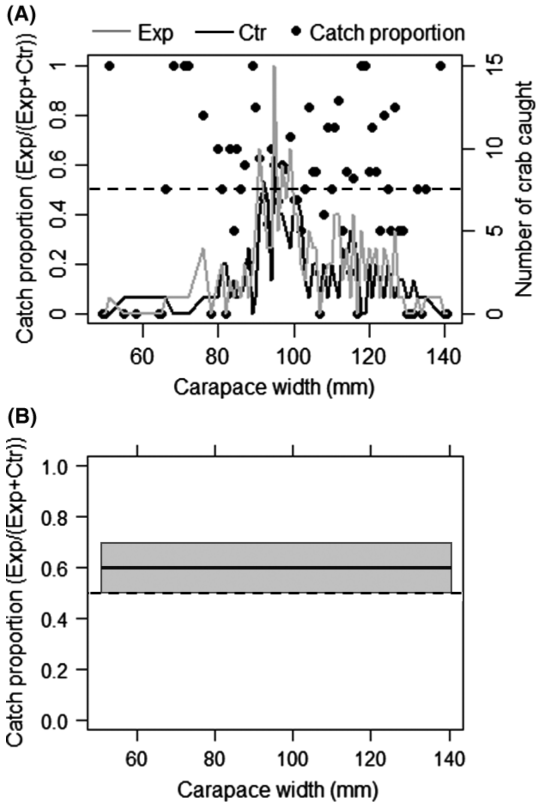

FIGURE 6. **(A)** The pooled length frequency curves and observed proportion by length for snow crabs caught by the luminescent and control traps of short-soaked duration. **(B)** The GLMM-modeled proportions of the number of crabs in each length class. "Exp" is the experimental trap; "Ctr" is the control trap. The horizontal dotted line at 0.5 indicates an even split between the luminescent trap and the control trap. Higher values indicate that more crabs at a given length were caught in the luminescent traps than in the control traps. The thick black line represents the modeled means, and the gray shaded areas indicate the 95% CI.

benefited baited traps that were illuminated with LED lights compared with identical traps with bait alone. They speculated that bait plays a pivotal role in the first days of soaking, but as the bait odor begins to deplete, traps with LED lights tend to perform better than their unilluminated counterparts because they continue to attract crabs regardless of the presence of bait.

Our fishing experiment demonstrated that luminescent traps were more effective at harvesting snow crabs than traditional traps when using short soak times. These findings document the first known empirical evidence on the positive attributes of luminescent netting/twine in fishing operations. To our knowledge, all previous evaluations of luminescent technologies have yielded negative or inconclusive results (e.g., Glass et al. 1993; Stone and Bublitz 1996; Werner et al. 2006). Although our findings are encouraging, we suggest caution in interpreting the results.

We recognize that the experimental replicates of each vessel and the number of fishing trips were relatively low in our fishing experiment. We also recognize that testing long soak times in one area and short soak times in another is unfortunate; however, the variation of soak times in the different areas was based on current fishing practices, ensuring relevance to the fishery. The results indicated a positive effect of the luminescent traps on the catch rate of snow crabs; however, the variation in the CPUE between vessels and fishing areas was large (an average of 4.2–26.8 crabs per trap). Given the number of remaining unanswered questions, we recommend a larger and more comprehensive study to investigate the effectiveness of luminescent traps in different environments, seasons, soak times, and fishing operations.

The use of light as a stimulus to attract and accumulate animals has existed for thousands of years, ranging from simple torches to sophisticated artificial illumination systems both above and below water (reviewed by Nguyen and Winger 2019). However, the mechanism that explains the behavioral response of animals to artificial light is not fully understood in many cases. A simple explanation is that animals are simply attracted to the light (Ben-Yami 1976). However, in some cases the mechanism may be more complicated. For example, evidence suggests that Atlantic Cod are not necessarily attracted to artificial light, but instead can be enticed to enter a trap in pursuit of prey, which are themselves attracted by the light (Humborstad et al. 2018; Utne-Palm et al. 2018). In the case of snow crabs, much remains unknown about how and why light increases the CPUE of traps. Recent work by Nguyen and Winger (in press) demonstrated that the location and orientation of a light is not important. These results suggest that precisely how the trap is illuminated is irrelevant to snow crabs. Rather, the authors speculated, whatever the light illuminates (e.g., the trap, seafloor, or even conspecifics), is less important than the light itself. These findings lend support for the hypothesis that snow crabs simply find the light to be a novel stimulus in a dark and barren landscape.

Light intensity and wavelength are known to affect animal behavior (see review by Nguyen and Winger 2019). We suggest that further research should be conducted to determine the potential benefits of increasing the percentage of luminescent fibers that are woven into the Euro-Glow product used in this study. We speculate that additional fibers may increase the catching performance of the trap. It also seems prudent to determine the wavelength emitted from the fibers and determine whether it can be optimized to the spectral sensitivity of snow crabs.

Artificial light is known to attract some species, but in other cases it can cause animals to move away from fishing gear, thereby reducing the incidental capture of nontarget species. For instance, attaching LED lights to gillnets reduced the bycatch of green turtles *Chelonia mydas* by over 60%, and Guanay cormorants *Phalacrocorax bougainvillii* by 85% (Ortiz et al. 2016; Mangel et al. 2018). Similar results were also found in set nets, which did not retain any loggerhead turtles *Caretta caretta* when deployed with LED lights (Virgili et al. 2018). Our study did not determine whether LED lights reduced the occurrence of bycatch, so additional experiments are required in this area.

The capture process of baited fishing gear involves multiple phases: attraction, capture, and retention (Winger et al. 2016). Bait plays a primary role in attracting animals to the trap by producing a plume of odor. Underwater camera observations have shown that animals typically swim or walk up-currrent to find the odor source that is being released from the bait (e.g., Winger and Walsh 2011; Jørgensen et al. 2017; Bergshoeff et al. 2018). The attraction phase depends on a variety of factors such as the satiation level of the targeted species, type and amount of bait, water velocity, density of the targeted species, and environment (Cyr and Sainte-Marie 1995; Grant and Hiscock 2009; Bergshoeff et al. 2018). The duration of attraction can vary from minutes to hours depending on the targeted species (Bergshoeff et al. 2018; Meintzer et al. 2018). Illuminated traps appear to offer snow crabs a novel stimulus. While precise functional explanations still remain unclear, evidence suggests that vision is very important in predator avoidance, food location, and prey capture for many marine species including invertebrates such as snow crabs (Frank et al. 2012). We hypothesized that the light emitted by the luminescent netting in this study was visible to snow crabs, explaining the increase in the observed CPUE. Much is understood about the minimum light intensity threshold for species such as mantis shrimp *Pullosquilla* spp., Japanese flying squids *Todarodes pacificus*, Pacific Chub Mackerel *Scomber japonicas*, loggerhead turtles, European Seabass *Dicentrarchus labrax*, and northern krill *Meganyctiphanes norvegica* (Cronin et al. 2001; Marchesan et al. 2005; Wang et al. 2007; Matsui et al. 2016; Utne-Palm et al. 2018). To our knowledge, very little is known about how snow crabs see and perceive light, or about the structure, function, or evolution of their eyes. Nguyen et al. (2017) demonstrated that crabs have positive phototactic behavior in response to white (wavelength of 456 nm) and blue (wavelength of 464 nm) LED lights, but the optimal light intensity for attraction was not measured. This provides an opportunity for future research on these mechanisms.

In conclusion, this study evaluated innovative luminescent netting for potential application in a snow crab fishery in eastern Canada. As expected, we found that the luminescent trap emitted light in a dark room over a period of several hours, with the resulting intensity and duration of luminescence dependent on the duration of UV exposure and the source of light. Our fishing experiment indicated that the experimental traps exhibited an increased CPUE (~55%) during short soak times (~1 d), but this benefit was undetected during longer soak times (~8 d).

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