Benefits of Using LED Light for Purse Seine Fisheries: A Case Study in Ninh Thuan Province, Viet Nam

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Fishers from Ninh Thuan Province, Viet Nam had been using two main kinds of lamps on their purse seine vessels, namely: fluorescent tube and metal-halide lamps. It was not until recently that the use of light emitting diode (LED) light for purse seiners was practiced in Ninh Thuan. Thus, a case study was carried out in the Province, the initial results showed that LED light achieved salient advantages in fishing. Although the power of LED light used on the experimental vessel was relatively lower than that of the control vessel (3 *vs.* 12 kilowatts), illumination and useful light areas increased by about 1.4 and 2.3 times, respectively. The total catch of purse seine vessel using LED light was significantly greater than that of the control, *i.e.* 59.2 MT from purse seine vessel with LED light and 51.9 from the control vessel. Catch from these vessels comprised scads (37.4%), skipjack tuna (33.8%), Indian mackerel (7.3%), largehead hairtail (6.0%), squid (4.3%), and other species (11.2%). The purse seine using LED light used 1,544 liters of fuel at appropriately 34,687,224 VND for three fishing trips while the control vessel consumed 4,680 liters for about 105,112,800 VND. The use of LED light for purse seine fishery is therefore considered efficient and cost-effective, especially in purse seine fisheries.

Located in the south-central part of Viet Nam, Ninh Thuan Province has a coastline of approximately 105 km and large fishing ground embracing an area of thousands km^2 with annual total available catch of about 50,000 metric tons (MT) comprising mostly high economic species, such as mackerel, tuna, horsehead fish, hairtail, red snapper, Indian mackerel, lobster, squid, cuttlefish, among others (Si, 2006). The fisheries sector is a very important source of income in Ninh Thuan, contributing about 20% of the gross domestic product (GDP), making this sector one of the most dynamic and fastest growing economic sectors of the Province. Its total catch of 64,069 MT in 2014 amounted to an export value of 17.5 million USD (Ninh Thuan Department of Capture Fisheries and Resources Protection, 2014).

Based on its fisheries development plan, Ninh Thuan Province intends to invest in offshore fishing fleet development to decrease inshore fishing pressure. In order to increase total catch to around 60,000 MT per year and improve the quality and value of its fishing products, the fisheries authorities of Ninh Thuan had recommended the use of newer technologies in fishing and fish handling (Decission No 1222/QĐ-TTG). Of the total number of 2,853 fishing vessels in Ninh Thuan Province, approximately 46% or 1,304 are purse seine vessels with light (Ninh Thuan Statistics Office, 2014), and the biggest challenge for purse seiners with light is fuel cost which accounts for 60% of the total cost per fishing trip (Thuy *et al.*, 2013).

Considering that each purse seine vessel spends between 50 to 150 liters of fuel per night (depending on engine capacity), the total fuel cost for purse seine vessel fleet in Ninh Thuan could range from 25 to 75 billion Vietnamese Dong (VND: 1 USD = 21,160 VND) per year. If fuel cost is reduced by 50-60 %, fishers could save 15-40 billion VND per year. In addition, using much fuel would not only increase the fishing cost, but also increases the emission of greenhouse gas (GHG) into the environment. According to Ozaki (2004), each kg of fuel an engine uses produces 3.19 kg of CO_2. This implies that purse seine vessel fleet in Ninh Thuan annually releases between 25,120 and 75,360 tons of CO_2 into the environment. Although, there had been no specific researches on air pollution due to fishing activity, environmental researchers affirmed that navigation and fishing activities emit 1.12 billion tons of CO_2 into the environment every year worldwide (Thuc, 2012).

Although the total fish catch in Ninh Thuan Province increased by approximately 7% annually from 2000 to 2013 (Ninh Thuận Statistical Yearbook, 2014), catch per unit of effort (CPUE) reduced from 0.71 tons/horsepower (HP) in 1995 to 0.46 tons/HP in 2001, to 0.31 tons/HP in 2010, and 0.26 tons/HP in 2013 (Son, 2011). On the contrary, the

total cost of fishing is continually increasing. For example, the cost of one fishing trip was only 55,000,000 VND in 2005 (Si, 2006) but in 2012 the cost per fishing trip was reported to rise to 85,000,000 VND (Son, 2011). Applying recent fishing technologies, such as the use of LED light in fishing could help reduce the cost while increasing fishing efficiency, and could economically benefit the fishers. LED light provides high illumination and is environmentally friendly, and could get 200 lumen/W at room temperature with typical lifetimes of 25,000-100,000 hours (US Department of Energy, 2006), 5 to 10 times higher than the lifetime of compact lamps, fluorescent tube, metal-halide and incandescent lamps which could be from 2,500 to 10,000 hours (Fink, 1978).

Other countries and some international organizations have encouraged the use of LED lights in fishing and other related sectors that spend much fuel (Kinh and Khoi, 2010). Matsushita (2012) reported that using LED light in squid jigging boats saved fishers about 46% of fuel, compared to halogen and metal-halide lamps. Furthermore, some researchers have shown that catch performance is not dependent on the type of lamps used, but on the scale of fishing gear, vessel capacity, density of fish, as well as light illumination and frequency (Yamashita, 2012). Using a suitable frequency of LED light could therefore increase fish catch by 15% saving about 65% on fuel compared to neon lights and metal-halide lights (Fang, 2011).

The Case Study

The case study which deals with the application of LED light source in fishing, present the status of light source equipping, initial efficiency of LED light usage in off-shore purse seince fishing vessels, including an evaluation of fuel usage, as well as fishing and environmental efficiencies. These results could fill whatever gaps that still exist on the advantages of using LED light in fishing.

Installing LED light in purse seine vessels in Ninh Thuan, Viet Nam

Survey of light sources of purse seines equipped with light in Ninh Thuan Province, Viet Nam

Data were collected through face-to-face interviews with fishers and owners of purse seine vessels using a questionnaire that includes basic information (*e.g.* name, address, position), fishing vessel information (*i.e.* name of ship, registration number, capacity), source of light used (*i.e.* power, light type, arrangement method, dynamo). Fishers were interviewed either as individuals or groups in their homes or onboard fishing boats, and selected at random. Onboard, the interviews were conducted in My Tan Fishing Port, where most purse seine vessels in Ninh Thuan Province are anchored.

Designing, installing the LED light system and experimental fishing

Two common types of lamps, *i.e.* fluorescent tubes and metal-halide lamps were installed on a purse seine vessel in Ninh Thuan Province (control vessel). The fluorescent tubes were fixed into troughs, each trough has five fluorescent tubes (40 W per tube) and each vessel carried between 12 and 14 troughs. In addition, 10 to 14 metal-halide lamps were alternately placed with the fluorescent tubes in the troughs. The total wattage of the light sources for offshore purse seine vessels ranged from 12.4 kW to 16.8 kW, the numbers of lamps and corresponding wattage depend on the vessel capacity and fishers' experience.

The light sources were installed at a height of 2.3-2.5 m with an inclination of 22.1°-51.3° (Son, 2011). In the experimental vessel, LED lights were installed using the same properties (*e.g.* illumination, light height and inclination) as those used for regular lighting systems in vessels as control. The same technical parameters (*e.g.* similar engine power, structure of fishing vessel, purse seine length and height) as those of the control were also used in the LED light experimental vessel. Moreover, these fishing vessels had to catch in the same fishing ground, using similar lighting and spend the same fishing time. The basic information of the experimental and control purse seine vessels are shown in **Table 1**.

Table 1. Characteristics of the experimental and control vessels

Categories	Experimental vessel with LED light	Control vessel
Registration number of vessel	NT 90578 TS	NT 90573 TS
Length of vessel (m)	19.50	19.30
Breadth of vessel (m)	5.50	5.20
Depth of vessel (m)	1.80	1.75
Horsepower of engine (HP)	370.00	350.00
Power of diesel generator (HP)	20.00	4.00
Number of crew in vessel (people)	16.00	16.00
Hung length of net (m)	515.00	510.00
Stretched depth of net (m)	150.00	150.00
Mesh size at bunt (mm)	21.00	21.00
Total light source (power)	3 kW (total LED light power)	12 kW (50 fluorescent tubes and 10 metal-halide lamps)

Purse seiners: *(above)* installed with common types of lamps (fluorescent bulbs and metal-halide lamps; and *(right)* installed with LED lights

Three experimental fishing activities were conducted: once in August 2013 corresponding with the southern fishing season (from October to May), another in October 2013 and the third in January, 2014, middle of the northern fishing season (from April to September). During the experimental fishing, fishing logbook was used to record the fishing trips' information, such as fishing position, casting time, net pulling time, fish species, total catch, and fuel consumed.

Measuring illumination on sea surface, transparency of sea water, and useful light area

Measurement of the llumination were taken on sea surface at the freeboards (0 m), in multiples of 5 m at varying distances from the freeboards, up to 1 lux (**Fig. 1**). At each position, 30 measurements were taken (Si, 2006) at the same positions where the illuminations were measured. Using a Secchi disc, the transparency of seawater was determined by the depth (distance) at which the disc disappears from sight (Ben Yami, 1987).

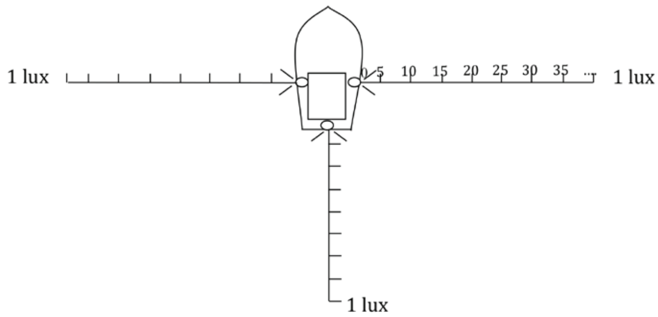

Fig. 1. Measuring the illumination of sea surface

Useful lighted areas are the lighted sea surface areas around the vessel where the extensibility is determined until illumination equals one lux. Since the LED light sources were installed on the left side, the light was distributed on the right and back sides of the cabin as shown in **Fig. 2**. Assuming an equal distribution of light and the circular area of the lighted areas, the total useful lighted areas was caculated using the following formula:

$S = S_1 + S_2 + S_3$, where:

S: useful lighted area
S_1= Π.R12
S_2= Π.R22
S_3= Π.R32
R_1, R_2, R_3: radii of lighted areas on the left, right and back sides of the vessel, respectively.
$R_1 = ½ D_1$; R_2 = ½ D2; $R_3 = ½ D_3$

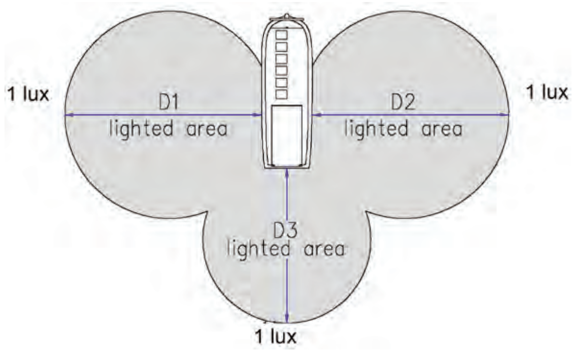

Fig. 2. Distribution of lighted areas around the vessel

Results and Discussion

Light sources of purse seiners equipped with light in Ninh Thuan Province, Viet Nam

Results from the survey of 35 purse seine vessels equipped with light indicated that two main types of light have been commonly used, namely: fluorescent and metal-halide lamps (**Table 2**). Usage of fluorescent and metal-halide lamps was from 20% to 33% and from 66% to 80%, respectively. The total light power on vessels with engine capacity of 75 and 89 HP was around 4.7 kW. For vessels with engine capacity ranging from 90 to 149 HP and from 150 to 249 HP, the light power was 6.84 kW and 10.14 kW, respectively. By contrast, the total light power of vessels with engine capacity of 250 HP dramatically increased to 16.8 kW.

Fishers have been using metal-halide and fluorescent lamps for quite some time as these are cheap; color temperature corresponds with sunlight (*i.e.* ~ 6,000K); and lamps could remain functional in the highly saline environment (Si, 2006). However, the use of metal-halide and fluorescent lamps has some advantages as well as disadvantages. Despite the aforementioned advantages, metal-halide and fluorescent lamps have some shortfalls (Si, 2006), which include having short lifespan (*i.e.* < 10,000 working hours); lamps usually have low luminescent output, *i.e.* < 60 Lumen/W for fluorescent lamp and 100 Lumen/W for metal-halide lamp (Grondzik, 2009); need many auxiliary spare parts (*e.g.* ballast, starter); require a stable electric power source; and light emitted could be harmful to users' eyes.

Illumination of the vessel with LED light and control vessel

Although total LED light power was 4 times less than the lights installed in control vessel (3kW in LED light versus 12kW in control vessel), illumination of LED light increased by 1.41 times. The maximum illumination produced by the LED light was 1,753 lux while it was only 1,252 lux in the control vessel (**Table 3**). Lighted areas following horizontal direction of the vessels, in LED light and control vessels were 65 m and 45 m, respectively. At equal inclinations, the total lighted area of the vessel with LED light was 9,459.25 m^2, whereas it was 3,885.75 m^2 in the control vessel. Due to the equal numbers of LED lights in the port and starboard (11 LED lights for each side), illumination, total lighted areas and volume were similar. Since there were 8 LED lights in the stern, illumination and total lighted areas were relatively lower than those in the freeboards.

Visibility of the Secchi disc

Results showed that the LED light could illuminate at greater depths than the fluorescent and metal-halide lamps. Specifically, the greatest depth at which the Secchi disc could be seen with LED light vessel was -40.6 m deep, while under the same condition, that of the control vessel measured -35.6 m deep (**Fig. 3** and **Fig. 4**). Considering that the lights have been blocked by the hull of the vessel, the depths at which the Secchi disc could be seen from the freeboards were low, *i.e.* 5.3 m for the LED light vessel and 4.3 m for the control vessel (**Fig. 3**). The greatest depth at which the Secchi disc could be seen from the sterns was at 5.0 m distance from the vessel, and its visibility decreases the further the vessels move (**Fig. 4**).

Total catch by species

From the three experimental fishing trips carried out, the total catch of the vessel equipped with LED light was approximately 1.2 times higher than that of the control vessel (**Fig. 5**). The total catch was 59.166 and 51.930 tons for the LED light-equipped and the control vessels, respectively, implying that the LED light was able to attract fishes better than the fluorescent and metal-halide lamps.

Table 2. Light source of purse seine vessels in Ninh Thuan Province

Type of light		Vessel capacity (HP)			
		75 - 89	90 - 149	150 - 249	≥250
Fluorescent lamp	Ave power (kW)	0.99	1.54	1.61	5.60
	Rate (%)	20.97	22.50	22.52	33.33
Metal-halide lamp	Ave power (kW)	3.72	5.30	5.53	11.20
	Rate (%)	79.03	77.50	77.48	66.67
Total average light power (kW)		**4.70**	**6.84**	**10.14**	**16.80**

Table 3. Average illumination by vessel with LED light and control

Horizonal distance from vessel (m)	Average illumination by control vessel (lux)			Average illumination by vessel with LED light (lux)		
	Starboard ± SD	Port ± SD	Stern ± SD	Starboard ±SD	Port ± SD	Stern ± SD
0	1,251 ± 3.1	1,252 ± 2.2	960 ± 1.6	1,751 ± 3.1	1,753 ± 2.5	1,346 ± 4.6
5	1,237 ± 2.5	1,235 ± 3.4	875 ± 2.3	1,736 ± 2.3	1,733 ± 3.2	1,232 ± 2.1
10	1,128 ± 1.5	1,126 ± 2.4	689 ± 4.7	1,579 ± 4.2	1,577 ± 2.1	1,143 ± 2.5
15	960 ± 2.8	962 ± 4.1	525 ± 3.6	1,428 ± 3.5	1,429 ± 4.5	979 ± 4.3
20	853 ± 3.2	856 ± 2.7	375 ± 3.1	1,325 ± 2.6	1,321 ± 4.2	850 ± 4.7
25	712 ± 4.2	714 ± 3.6	157 ± 2.5	1,192 ± 1.9	1,198 ± 2.8	730 ± 2.6
30	526 ± 3.5	528 ± 4.3	67 ± 2.7	982 ± 2.7	980 ± 3.8	613 ± 2.2
35	215 ± 2.9	215 ± 2.8	1 ± 0.6	761 ± 1.7	760 ± 2.5	467 ± 2.8
40	49 ± 4.6	47 ± 3.1	-	534 ± 2.4	530 ± 4.1	312 ± 3.4
45	1 ± 0.4	1 ± 0.3	-	384 ± 4.2	387 ± 3.3	204 ± 2.9
50	-	-	-	220 ± 2.6	221 ± 4.3	79 ± 1.8
55	-	-	-	100 ± 1.3	103 ± 1.9	20 ± 2.1
60	-	-	-	54 ± 2.2	54 ± 2.7	1 ± 0.5
65	-	-	-	1 ± 0.7	1 ± 0.4	-

Both the LED light-equipped and control vessels caught similar species of fish (**Fig. 6**). The catch included scads (38.13% for control vessel; 37.39% LED light-equipped vessel), skipjack tuna (33.24% for control; 33.80% for

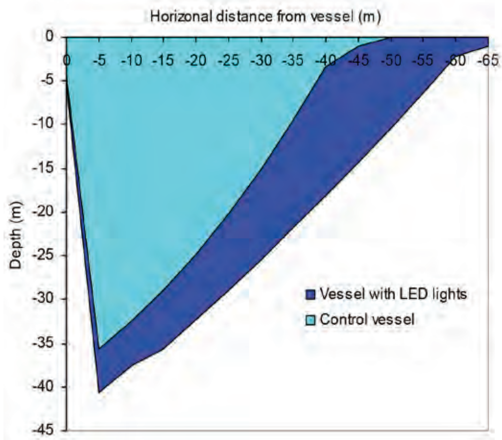

Fig. 3. Average depth at which Secchi disc was visible from the freeboards

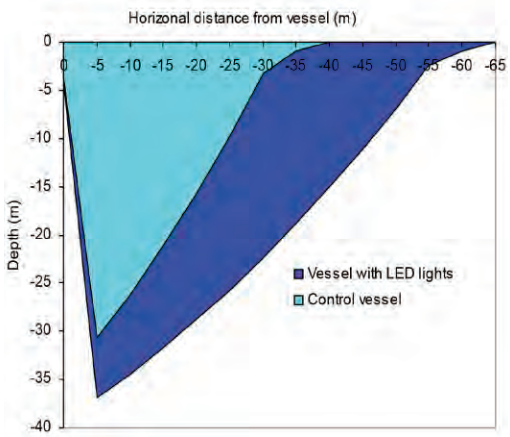

Fig. 4. Average depth at which Secchi disc was visible from the sterns

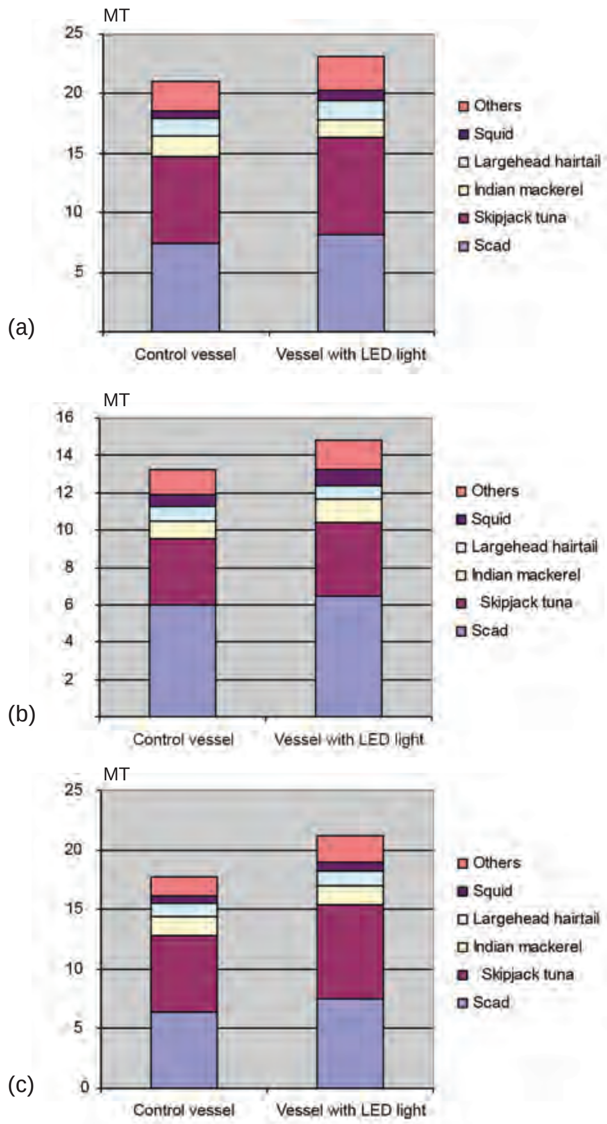

Fig. 5. Total catch of LED light equipped and control vessels: **(a)** fishing trip 1, **(b)** fishing trip 2, and **(c)** fishing trip 3

LED light), Indian mackerel (8.08% for control; 7.33% for LED light-equipped), largehead hairtail (6.66% for control and 5.96% for LED light-equipped), squid (3.67% for control; 4.29% for LED light-equipped), and other species (10.23% for the control vessel and 11.23% for the LED light-equipped vessel).

The results also indicated that in terms of fishing time, 80.0% sets from the LED light-equipped vessel was able to catch fish from 22:00 to 24:00 hours whereas 92.1% sets from the control vessel fished only after 23:00 hours. This means that the LED light-equipped vessel was quick enough to attract fish than the fluorescent and metal-halide lamps. In other words, the fish attraction time of LED light was about five hours, while fish attraction time of fluorescent and metal-halide lamps was six hours.

Cost of fuel used

Based on information from the three experimental fishing trips, the control vessel used a total of 4,680 liters of fuel which is equivalent to 105,112,800 VND, while the purse seine with LED light used only 1,544 liters equivalent to 34,687,224 VND, which is about 33% of the fuel used by the control vessel (**Table 4**). Fuel used during fishing trips includes fuel for the main engine and for the power generator. It should be noted that the experimental and control vessels operated at the same time and in the same fishing ground. The main engines of the vessels have similar power (370 HP for the experimental vessel and 350 HP for the control vessel). Therefore, the difference of fuel usage was from the power generator. The results therefore showed considerable amount of savings when fishers equip their vessels with LED light compared with using fluorescent and metal-halide lamps. In addition, saving 3,136 liters of fuel from three fishing trips is environmentally significant because the LED light-equipped purse seine vessel could decrease the amount of CO_2 emissions into the environment by 8.4 tons, since 1.00 kg of diesel fired would produce 3.19 kg of CO_2 (Ozaki, 2004).

In terms of total catch, the fishing trips caught almost the same quantity, thus, there is no need to increase the catch per unit of effort. Therefore, fishing efficiency in this case would depend largely on the cost of operation, especially

Table 4. Total cost of fuel used during the three experimental fishing trips

Fuel information	Control vessel	Vessel quipped with LED light
Total consumed fuel (liters)	4,680	1,544
Price (VND)	22,460	22,460
Total cost of fuel (VND)	105,112,800	34,687,224

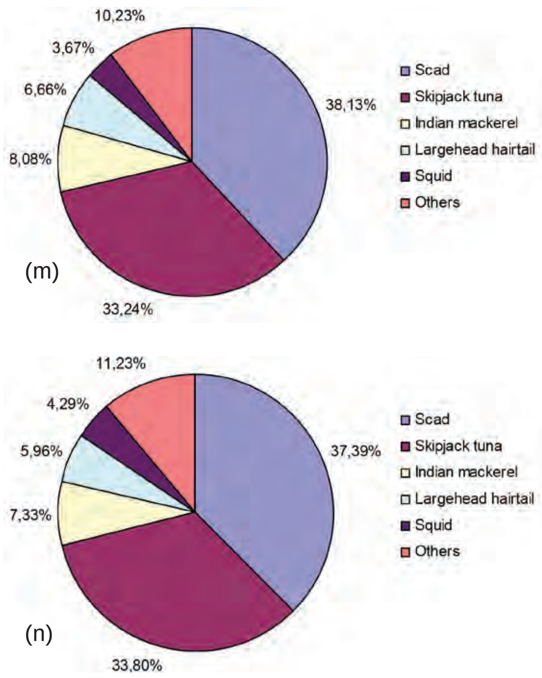

Fig. 6. Species composition of fish catch: **(m)** control vessel, and **(n)** vessel with LED light

fuel cost because fuel alone accounted for 60% of the total fishing operation costs. Furthermore, the price of diesel which is continually increasing should be taken into account. Considering that the use of LED light in fishing relatively decreases the volume of fuel consumed, such practice could be promoted as it is beneficial for the fishers through decreased operating costs that eventually leads to increased incomes, and less CO_2 emitted to the atmosphere.

Conclusion

This case study was the first attempt to apply LED light as source of light for purse seine vessels in Viet Nam. Although the initial research results are promising in terms of illumination, catch and fuel expenses, other factors such as structure, illumination, color and index protection of LED light need to be considered in future studies. Furthermore, the price of LED light is about 8-10 times higher than fluorescent and metal-halide lamps and fishers might be hesitant to use LED light as its initial cost is quite exorbitant. Besides, fishers are not yet familiar with the use of LED light in fishing and might not be willing to adopt it immediately. However, there is a need to make the fishers aware that in the long term, using LED light in fishing could be economically and environmentally profitable. Although the initial cost of installing the LED light is high, the cost of operating and maintaining it is low, particularly because the LED light has a relatively longer lifespan than that of compact, fluorescent and metal-halide lamps. Nevertheless, the type of lamps that fishers install on purse seine vessels in Ninh Thuan Province also depends on their habits, which indicated that fluorescent tubes and metal-halide lamps are the most common types of lamps that fishers install on vessels. Even if the cost of these lamps is cheap but the lifespan is shorter than LED lights and more fuel is utilized. The initial results also showed that the use of LED light in fishing improves fishing efficiency. Luminescent outputs and fish attractions of LED lights are relatively higher than that of fluorescent and metal-halide lamps. Moreover, purse seine vessels with LED light saved 77% of fuel consumed compared to the control vessel, while the total catch of the vessel with LED light increased by 12.23%. The species caught by the purse seine vessels with LED light were identical to that of the control vessel, and included scads, skipjack tuna, Indian mackerel, largehead hairtail, squid, and other species that were not identified.

References

Ben Yami. 1987. Fishing with Light. Food and Agricuture Organization of the United Nations. Henry Ling Ltd, the Dorset press; 31 p

Decision No 1222/ QĐ-TTg on the Planning of Strategies for Social Economic Development of Ninh Thuan Province up to 2020. Dated 22.7.2011

Fang, M. C. 2011. Research of fish lamps using the high power LED light on fishing boat. Proceedings of Taiwan – Japan Fisheries Research Symposium. Tzu Chi University; 7 September 2011

Fink, D. G., H. Beaty and H. Wayne. 1978. Standard Handbook for Electrical Engineers (11th ed.). McGraw Hill ISBN 978-0-070-20974-9; 22-17

Grondzik, T., A. G. Kwok., B. Stein and J. S. Reynolds. 2009. Mechanical and Electrical Equipment for Buildings, 11th Ed. USA: John Wiley & Sons. ISBN 0-470-57778-9; 555–556

Kawamura, G. 1983. Vision and Behaviour of Fish in the Vicinity of Fish Lamp. Proc. Intl. Conf. Dev. Managt. Trop Living Aquat. Resources. Serdang, Malaysia, 2-5 August 1983; 197-204

Kinh, N. T., P. H. Khoi. 2010. LED lamps for general lighting. Vietnam Energy Efficient Public Lighting (VEEPL) Project

Matsushita, Y., T. Azuno., Y. Yukiko. 2012. Fuel reduction in coastal squid jigging boats equipped with various combinations of conventional metal-halide lamps and low-energy LED panels. Fisheries Research. Volumes 125 – 126, August 2012; 14-19

Ming-Chung Fang. 2011. Research of Fish Lamps Using the High Power LED Light on the Fishing Boat. Taiwan-Japan Fisheries Research Symposium, 7 September 2011

Losev, O. V. 1927. Telegrafiya i Telefoniya bez Provodov 44: 485–494

Luong, N. T. 2009. Economic performance indicators for coastal fisheries: the case of pure-seining in Khanh Hoa, Vietnam. Tromsø, University of Tromsø; 76 p

Ninh Thuan Statistics Office. 2014. Ninh Thuận Statistical Yearbook 2013, Statistics Publisher

Ninh Thuan Department of Capture Fisheries and Resources Protection. 2014. Annual Rreport of the Department of Capture Fisheries and Resources Protection of Ninh Thuan Pprovince, Vietnam (*Vietnamese*); 23 p

Ozaki, M., J. Davison., J. Minamiura., E. S. Rubin., D. W. Keith., C. F. Gilboy., M.Wilson., T. Morris., J. Gale and K. Thambimuthu. 2004. Marine Transportation of CO_2. Proceedings of the 7th International Conference on Greenhouse Gas Control Technologies, Vancouver, Canada, 5-9 September 2004; 2535-2539

Round, H. J. 1907. A Note on Carborundum. Electrical World 19: 309

Shigeo, H., C. Miyata., T. Yamazaki., S. Narintharangkura., S. Supongpun and P. Saikliang. 1983. Preliminary study on estimating effective light intensity for purse seine fisheries in Thailand, Joint Research Paper 2; 1-40

Sugeng, H. W and M. S. Baskoro. 2003. Output performance of pressure kerosene lamp for the floated bamboo-platform liftnet (bagan) in Indonesia. Laboratory of Fish Behavior, Tokyo Uni. Fish; 2-13

Si, N. D 2006. Researching some solutions to improve efficiency of the light source using of the offshore purse seiner with light. PhD thesis. Nha Trang University: 233p

Son, N.N 2011. Evaluation of efficiency light source using on purse seiner in Ninh Thuan province – catching small pelagic species. Master's degree thesis. Nha Trang University; 69p

Thuc, T., H. T. L. Huong., D. M. Trang. 2012. Integrating climate change problem into plan of economic and social development. Vietnam Publishing House of Natural Resource, Environment and Cartography

Thuy, P. T. T., O. Flaaten and N. T. K. Anh. 2013. Remuneration System and Economic Performance: Theory and the Vietnamese Small Scale Fisheries. Marine Resource Economic Journal 28(01)

Yamashita, Y., M. Yoshiki and T. Azuno. 2012. Catch performance of coastal squid jigging boats using LED panels in combination with metal-halide lamps. Fisheries Research. Volume 113 (2012): 182-189

US Department of Energy. 2006. Lifetime of white LEDs. Building Technology Program. *http://web.archive.org/web/20090410145015/http:/www1.eere.energy.gov/buildings/ssl/lifetime.html*. Retrieved 10.2.2014

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