

Small-scale Squid Large Cast-Net Fisheries during Waxing and Waning Moon Phases in the Klongwan Coastal Area, Prachuap Khiri Khan Province, Thailand

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ABSTRACT

A squid catch study was conducted through onboard surveys using large cast-net fishing at different operations between waxing and waning moon phases in the Klongwan coastal area, Prachuap Khiri Khan province in September 2014, January, March and May 2015. The catch and CPUE, including the income obtained, were analyzed. Results showed that the number of caught species from this fishery during the 12th–15th days of a waxing moon was 27 species (4 species of squids, 15 species of marketable value and 8 species of discards) and during the 12th–14th days of a waning moon was 28 species (3 species of squids, 17 species of marketable value and 8 species of discards). The average catch rate of target species (Loliginid squids, *Loligo* spp.) and non-target species, catch composition, CPUE and income from this fishery between waxing and waning moon phases were not significantly different ($p > 0.05$). This study indicated that lunar cycles did not have an impact on squid catch from fishing by large cast-net. Fishing during waxing and waning moon phases produced a rather low daily income, at THB 591.80 and 245.78, respectively. The main daily operating costs were for light generation, at 57.1–71.7% and 53.2–65.5% of total costs, respectively.

Keywords: Small-scale squid fishing, Large cast-net, Lunar cycles, Klongwan coastal

INTRODUCTION

Squid fishing has attracted interest worldwide over the last two decades due to its commercial potential under the present conditions of targeting species lower down the food web (FAO, 2011). In Thailand, squid is caught in the Andaman Sea and the Gulf of Thailand, as a commercially important species for coastal fisheries. It also commands a high domestic market price. However, due to overfishing, the catches of squid from the sea have shown a downward trend in Thailand since 2009 (Department of Fisheries, Thailand 2014). Therefore, knowledge about this fishing process would be useful to improve

returns, which is important for future job stability in fisheries. In Thailand, among the various harvesting methods for squid, the large cast-net is considered a highly selective fishing method, especially in the coastal areas of southern Thailand. It uses a type of falling net that targets Loliginid squids (*Loligo* spp.) and is widely used in Prachuap Khiri Khan province (Arkronrat and Oniam, 2014; Arkronrat *et al.*, 2014; Arkronrat and Boutson, 2013; 2015). Even though most fishers have predicted that the future catch trend for such fishing will get worse, they still persist whilst having to address the main problems of decreasing catch size and increasing fishing costs (Arkronrat and Boutson, 2015).

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Currently, studies on squid fishing using large cast-nets are very limited. Therefore, it is necessary to study the factors that affect the catch size or weight using this fishing method. The lunar cycle is commonly observed in the movements, feeding and reproduction of marine and freshwater fish and invertebrates and there are also strong beliefs among people involved in fishing that fish catches in fisheries depend on the moon phase (Bigelow *et al.*, 1999; Chiou *et al.*, 2003; Mookkaew *et al.*, 2011; Ulas and Aydin, 2011). Knowledge of lunar cycles is also of interest in squid fishing because these cycles are believed to influence catch rates. In the current study, catches and income from large cast-net fishing at different operational times (waxing and waning moon phases) in the Klongwan coastal area, Prachuap Khiri Khan province, were considered using data obtained from accompanying fishing operations. The main features of this type of fishing involved the examination of catch size, catch per unit of effort (CPUE) and income.

MATERIALS AND METHODS

Study site

The study was conducted at the Klongwan coastal area, Prachuap Khiri Khan province, southern Thailand (Figure 1) at $11^{\circ}42' - 11^{\circ}45' \text{ N}$ and $99^{\circ}47' - 99^{\circ}49' \text{ E}$ containing the fishing grounds for small-scale squid fishing about 2–4 km offshore and at sea depths of about 8–15 m (Arkronrat and Boutson, 2013).

Fishing gear and fishing method

The study used a wooden boat with a length of 9 m and a beam of 3 m fitted with an 85 Hp diesel engine for the squid fishing operation. The fishing gear structure was similar to that of a big cast net with a total length of 14 m from head to foot. The main net was nylon but the head and foot of the net were made of polyethylene with a mesh size of 25 mm.

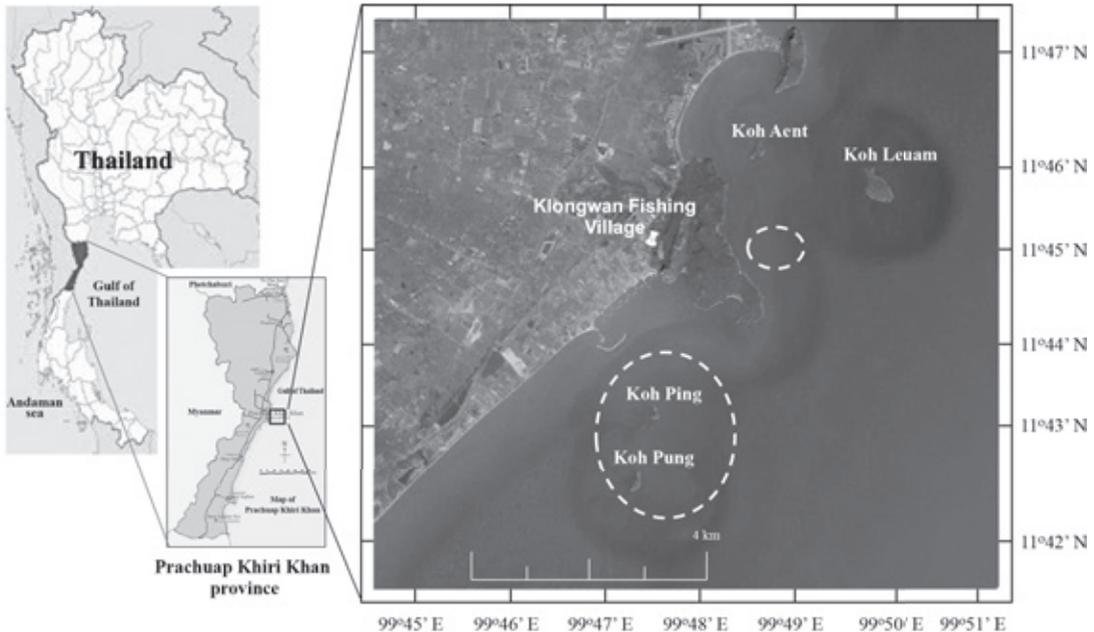


Figure 1. Location of small-scale squid large cast-net fishing grounds (⊙) in the Klongwan coastal area, Prachuap Khiri Khan province, Thailand (adapted from Arkronrat and Boutson, 2013).

The net mount diameter was 38 m, attached with stainless steel rings and lead sinkers. The ring diameter was 5 cm, with a weight of 70 g per ring and the ring interval was 70 cm (52 rings in total). Each lead weight was 125 g with a lead interval of 25 cm (152 units in total) as shown in Figure 2. The net was tied to bamboo booms on the starboard side of the boat where a 5 kW generator was installed. Ten 250 W halogen lamps tied to bamboo booms around the boat were used to attract the squid. A 500 W spotlight was installed starboard for light intensity reduction.

The fishing method commenced with spreading out a pair of 10 m bamboo booms that were installed

on the foredeck and stern; then, the light booms were spread and the lights were turned on. When sufficient squid had aggregated under the light, the foot of the net was set as a square shape on the booms above the surface and the head part was kept onboard.

The lamps were turned off so that only the spotlight was used to reduce the light intensity. The squid then gathered under the spotlight and the four sides of the net were dropped into the water at the same time. The rope inserted through the rings at the foot of the net was tightened to close the net which was then hauled onto the boat and the catch was released from the head net. There were 3–4 separate catches per night.

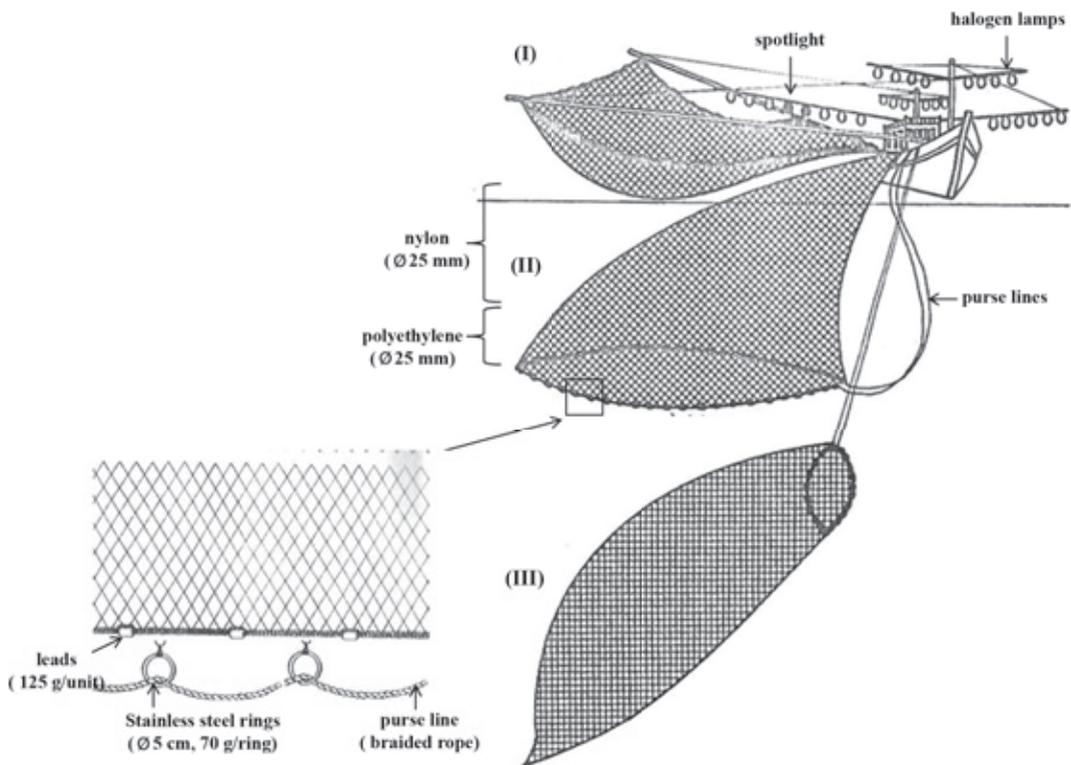


Figure 2. Structure and operation of squid large cast-net fishing (adapted from Supongpan and Sinoda, 1995): (I) the large cast-net set on two bamboo booms, (II) the net submerged into the water for a shoal of squid aggregated in an area of spotlight reducing the light intensity, (III) the mouth of the large cast-net pursed by lines and hauled back onto the boat.

Squid large cast-net fishing was conducted via onboard surveys for fishing on the 15th, 12th, 12th and 14th days of waxing moon (8 September 2014, 31 January 2015, 1 March 2015 and 1 May 2015, respectively) and on the 13th, 14th, 14th and 12th days of a waning moon (21 September 2014, 18 January 2015, 18 March 2015 and 14 May 2015, respectively).

Data collection

The study was conducted using onboard surveys of large cast-net fishing twice a month. Data was recorded for catch analysis consisting of species, size (body weight), quantity, catch composition and CPUE, including the income in different lunar cycles. The lunar cycle consisted of two moon phases—waxing and waning. A waxing moon was defined as any time after a new moon up until a full moon. On the other hand, a waning moon was defined as any time after full moon until a new moon. Moon phase information was obtained from the Royal Thai Navy Hydrographic Department website (Royal Thai Navy, 2014).

The weight of catches was recorded in kilograms from a 10% simple of the total catch. The specimen size measured the body weight (in grams) of target species that were divided into main target and minor target species. The catch data was expressed in terms of the CPUE and the CPUE and income or net cash return were calculated using Equations 1 and 2 from Arkronrat and Boutson (2013):

$$\text{CPUE (kg/hr)} = \frac{\text{weight of total catch (kg)}}{\text{time operating (hr)}} \quad (1)$$

$$\text{Net income (Thai baht)} = \frac{\text{revenue from total catch} - \text{operating costs}}{\quad} \quad (2)$$

The operation commenced with turning on the lights until dropping the net to catch the squid and operating costs included items such as fuel, bait, ice and food.

Statistical analysis

The difference between means, data on catches, CPUE and income of squid large cast net fishing during waxing and waning moon phases were tested using independent-sample *t*-tests at the 95% level of confidence. Data were analyzed using the IBM SPSS Statistics for Windows (Version 21.0; IBM Corp., Armonk, NY, USA).

RESULTS

Catches and catch composition

The catch results indicated that the number of species from squid large cast-net fishery during a waxing moon was 27 species, consisting of 4 species of squid, 15 species of marketable value and 8 species of discard, and during a waning moon was 28 species, consisted 3 species of squid, 17 species of marketable value and 8 species of discard, as shown in Table 1.

The size (body weight) of the main target species (Lologinid squids, *Loligo* spp.) caught using large cast-net fishing in waxing and waning moon phases is shown in Figure 3. There was no significant difference (*t*-test, $p = 0.708$) between the average body weight of Lologinid squids from the waxing moon catch (41.61 ± 29.91 g, $n = 143$) and the waning moon catch (43.28 ± 29.36 g, $n = 64$).

The main target species (Lologinid squids, *Loligo* spp.) and minor target species (Cuttlefish, *Sepia* spp. and Bigfin reef squid, *Sepioteuthis lessoniana*) were found every collection time for both waxing and waning moon phases indicating there was no impact on target species from the moon phase. In addition, there was no significant difference between waxing and waning moon phases for the catch of Lologinid squids (11.46 ± 12.32 kg/day and 6.52 ± 8.58 kg/day, respectively, *t*-test; $p = 0.535$), for the catch of other squid (0.23 ± 0.22 kg/day and

Table 1. Total catches of squid large cast-net fishing during different lunar cycles in the Klongwan coastal area on September 2014, January 2015, March 2015 and May 2015.

Common name	Scientific name	Lunar cycle	
		Waxing moon	Waning moon
<i>Main target species</i>			
Lologinid squids	<i>Loligo</i> spp.	√	√
<i>Minor target species</i>			
Cuttlefish	<i>Sepia</i> spp.	√	√
Bigfin reef squid	<i>Sepioteuthis lessoniana</i>	√	√
Octopus	<i>Octopus</i> spp.	√	
<i>Marketable value species</i>			
Mullet	<i>Mugil</i> spp.	√	√
Queenfish	<i>Scomberoides</i> spp.	√	√
Mackerel	<i>Rastrelliger</i> spp.	√	√
Deepbody Sardinella	<i>Sardinella</i> spp.	√	√
Yellowtail scad	<i>Caranx</i> <i>mate</i>	√	√
Hairtail	<i>Trichiurus</i> spp.		√
Scad	<i>Alepes</i> spp.	√	
Torpedo scad	<i>Megalaspis cordyla</i>	√	
King mackerel	<i>Scomberomorus</i> spp.	√	
Croaker	Family Sciaenidae		√
Indian threadfin	<i>Polydactylus indicus</i>		√
Yellow-stripe trevally	<i>Selaroides leptolepis</i>		√
Sardinella	<i>Sardinella</i> spp.		√
Longjaw thryssa	<i>Thryssa setirostris</i>	√	
Hamilton's thryssa	<i>Thryssa hamiltonii</i>	√	√
Barracuda	<i>Sphyaena</i> spp.	√	
Rabbitfish	<i>Siganus</i> spp.	√	
Grunter	<i>Terapon</i> spp.		√
Whitespotted spinefoot	<i>Siganus canaliculatus</i>		√
Blue swimmer crab	<i>Portunus pelagicus</i>	√	√
Banana shrimp	<i>Fenneropenaeus merguensis</i>	√	
Shrimp	<i>Metapenaeus</i> spp.	√	√
Mantis shrimp	<i>Miyakea nepa</i>		√
Surf clam	<i>Paphia undulata</i>		√
<i>Discard species</i>			
Congaturi halfbeak	<i>Hyporhamphus limbatus</i>	√	√
Yellow finned ponyfish	<i>Leiognathus</i> spp.	√	√
Haneda 's ponyfish	<i>Secutor</i> spp.	√	√
Tropical silverside	<i>Atherinomorus duodecimalis</i>	√	√
Sumatran silverside	<i>Hypoatherina valenciennei</i>	√	√
Green rough backed blowfish	<i>Lagocephalus</i> spp.	√	√
Shortfin lizardfish	<i>Saurida micropectoralis</i>	√	
Anemone crab	<i>Dorippe facchino</i>	√	√
Pebble crab	<i>Leucosia</i> spp.		√

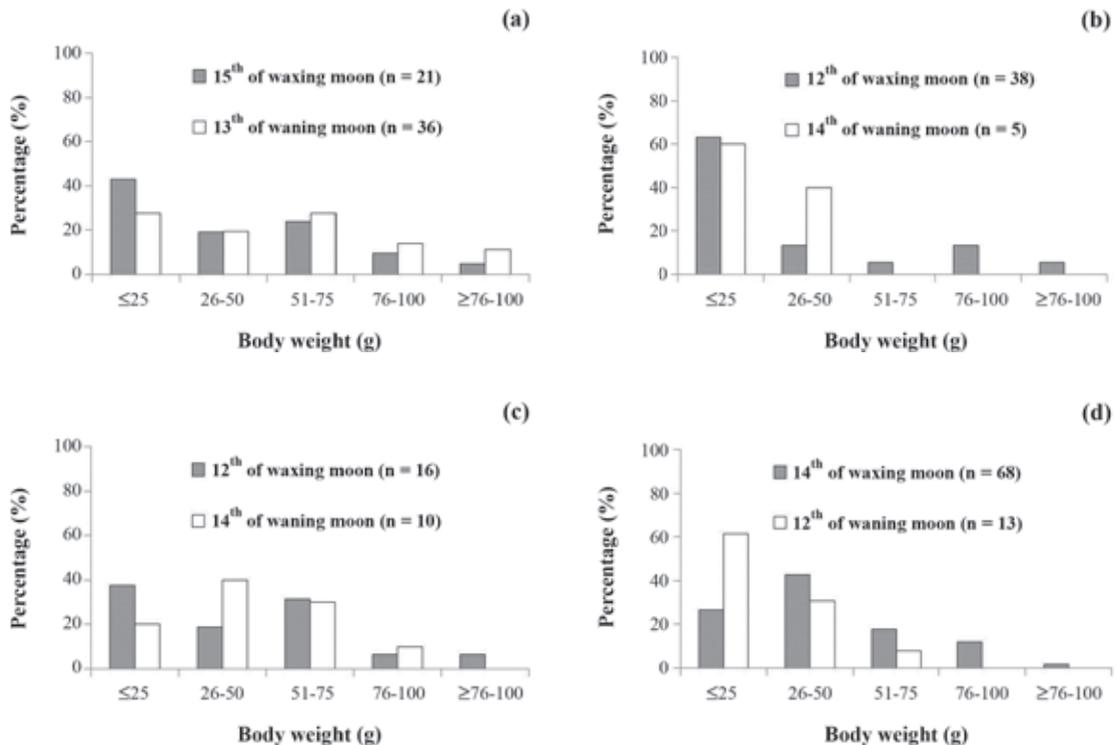


Figure 3. The size (body weight) of target species (Lologinid squids, *Loligo* spp.) sampled from large cast-net fishing during different lunar cycles: (a) September 2014; (b) January 2015; (c) March 2015; (d) May 2015.

0.37±0.71 kg/day, respectively, *t*-test; *p* = 0.705), for marketable value species (2.70±3.30 kg/day and 1.10±1.22 kg/day, respectively, *t*-test; *p* = 0.397) and for discard species (0.14±0.05 kg/day and 0.45±0.46 kg/day, respectively, *t*-test; *p* = 0.278), of the total catch (14.53±11.40 kg/day and 8.44±7.87 kg/day, respectively, *t*-test; *p* = 0.413) as shown in Table 2.

During the study, in the waxing moon phase, the catch composition by weight of Lologinid squids was 28.6–96.4% (67.3±34.4%), of other squid was 0.3–4.5% (2.0±1.7%), of marketable value species was 0.0–64.1% (29.1±33.0%) and of discard species was 0.3–2.9% (1.6±1.1%). In the waning moon phase, the catch composition by weight of Lologinid squids was 13.2–97.7% (54.0±37.7%),

of other squid was 0.0–20.9% (6.4±9.9%), of marketable value species was 1.0–62.1% (29.0±28.2%) and of discard species was 1.3–20.2% (10.6±9.8%) as shown in Figure 4. The result showed that the catch composition of squid large cast net fishing during waxing and waning moon phases were not significantly differences (*t*-test, *p* > 0.05).

Catch per unit of effort (CPUE)

The CPUE comparison for squid caught using large cast-net fishing in waxing and waning moon phases is shown in Figure 5. The results show that there was no significant difference between the waxing moon phase and the waning moon phase for the average CPUE of the main target species (1.29±

1.52 kg/hr and 0.75±1.02 kg/hr, respectively, *t*-test; *p* = 0.579), minor target species (0.02±0.03 kg/hr and 0.05±0.09 kg/hr, respectively, *t*-test; *p* = 0.641), marketable value species (0.26±0.31 kg/hr and 0.14 ±0.15 kg/hr, respectively, *t*-test; *p* = 0.534) and discard species (0.01±0.00 kg/hr and 0.05±0.04 kg/hr, respectively, *t*-test; *p* = 0.116) as shown in Figure 6.

Income and operating costs

The structure of income differed between the waxing and waning moon phases as shown in

Table 3. Under a waxing moon, the estimated composition of operating costs was fuel consumption 88.5–90.8%, meals onboard 5.5–8.4% and ice for bait storage 2.4–3.3% of the total cost. Under a waning moon, the composition of operating costs was fuel consumption 87.1–91.9%, meals onboard 4.9–9.7% and ice for bait storage 2.7–3.2% of the total cost. The average daily net income from squid large cast-net fishing during the waxing and waning moon phases was THB 591.80 and THB 245.78, respectively, and these were not significantly different (*t*-test, *p* = 0.573).

Table 2. Total catch (kg/day) of target and non-target species from squid large cast-net fishing during different lunar cycles.

Date	Waxing moon phase					Waning moon phase				
	Target species		Non-target species		Total catch	Target species		Non-target species		Total catch
	S	OS	MVs	Ds		S	OS	MVs	Ds	
Sep-14	8.20	0.12	0.00	0.18	8.50	19.10	0.00	0.19	0.26	19.55
Jan-15	1.34	0.21	3.01	0.14	4.70	0.13	0.05	0.63	0.20	1.01
Mar-15	6.90	0.04	7.24	0.18	14.36	4.50	0.00	0.68	1.14	6.32
May-15	29.40	0.53	0.55	0.08	30.56	2.33	1.44	2.90	0.20	6.86
Mean	11.46	0.23	2.70	0.14	14.53	6.52	0.37	1.10	0.45	8.44
±SD	±12.32	±0.22	±3.30	±0.05	±11.40	±8.58	±0.71	±1.22	±0.46	±7.87

Note: S = Lologinid squids (*Loligo* spp.); OS = other squid; MVs = other marketable value species; Ds = discarded species.

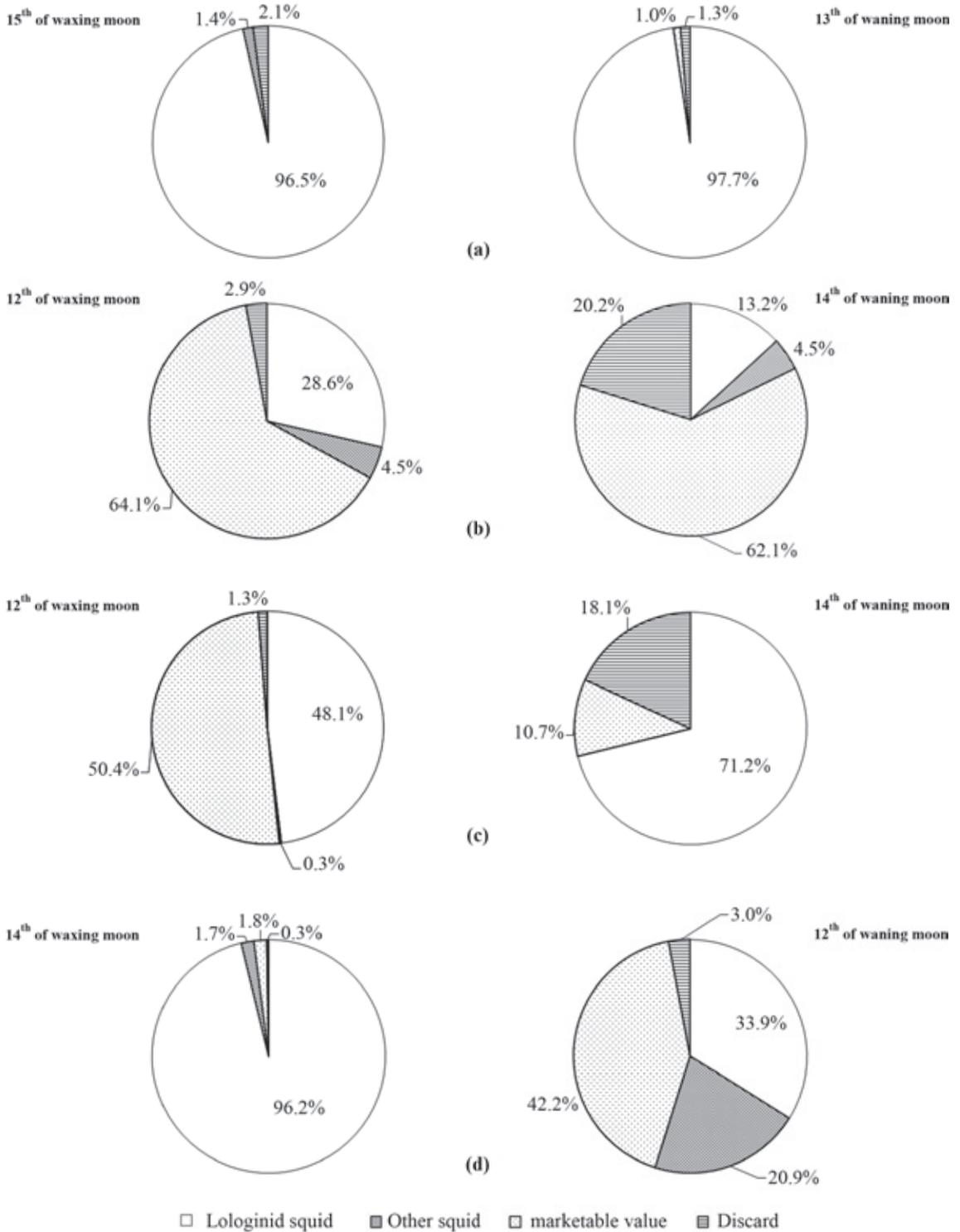


Figure 4. Comparison of catch composition by weight from squid large cast-net fishing during different lunar cycles: (a) September 2014; (b) January 2015; (c) March 2015; (d) May 2015.

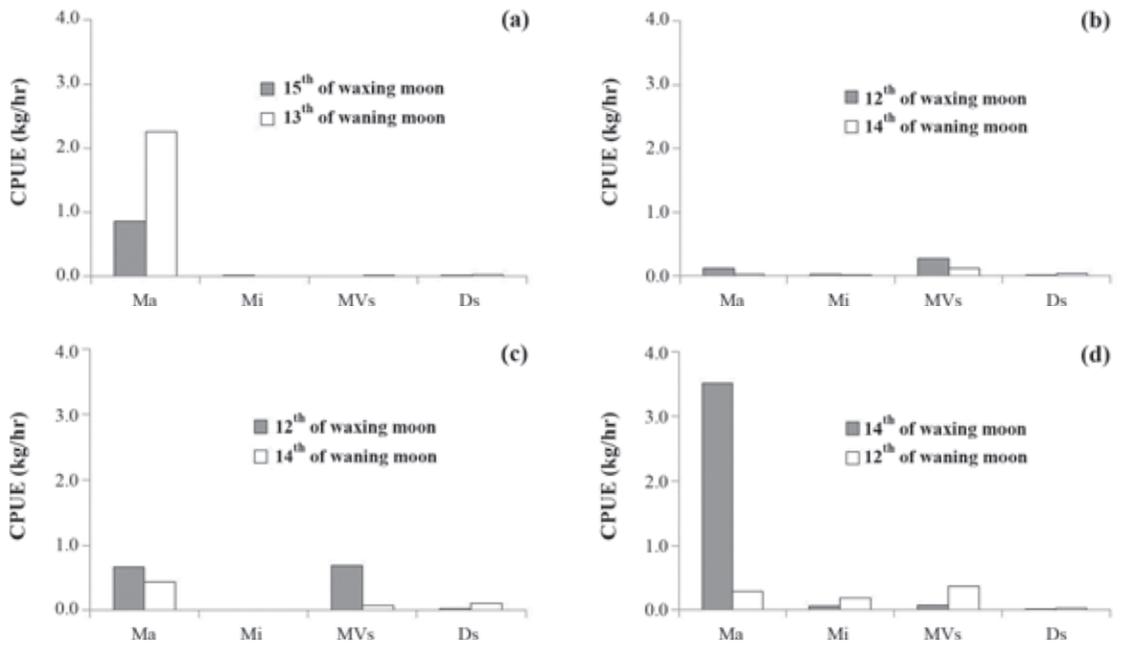


Figure 5. CPUE of main target species (Ma), minor target species (Mi), marketable value species (MV) and discarded species (Ds) from the large cast-net fishery at different lunar cycles: (a) September 2014; (b) January 2015; (c) March 2015; (d) May 2015.

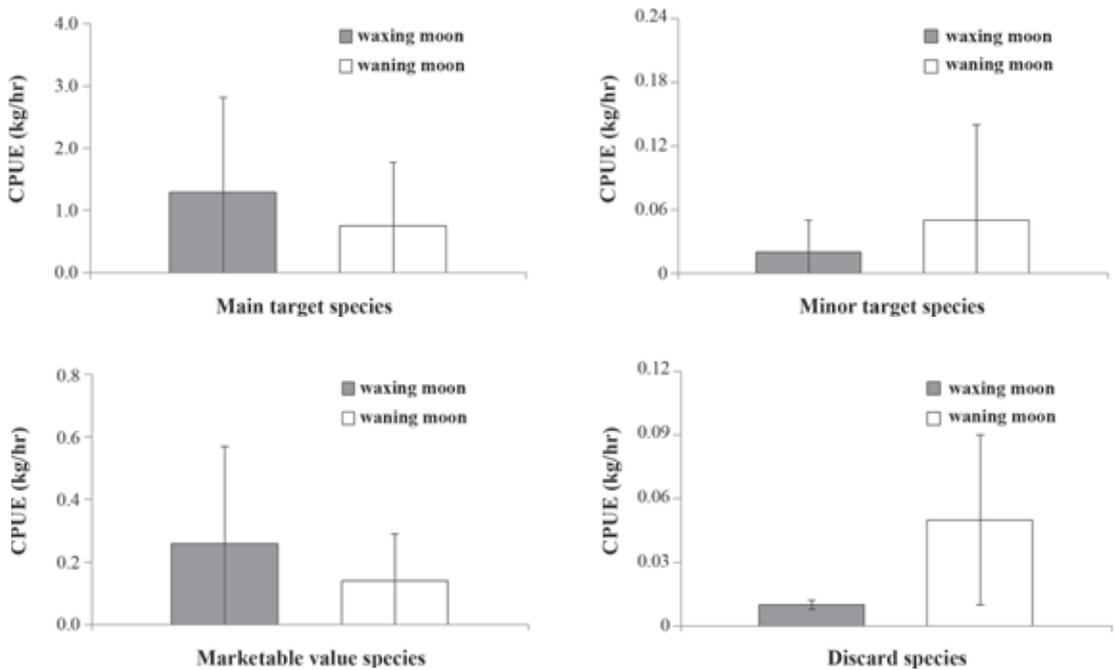


Figure 6. Comparison of CPUE (mean \pm SD.) from squid large cast-net fishing during different lunar cycles from four operations ($n = 4$).

Table 3. Operating costs and income of squid large cast-net fishery during different lunar cycles in September 2014, January 2015, March 2015 and May 2015.

Items	Waxing moon phase				Waning moon phase				
	8 Sep	31 Jan	1 Mar	1 May	21 Sep	18 Jan	18 Mar	14 May	
<i>General information</i>									
Distance from shore to fishing ground (km)	4.2	7.2	3.3	2.9	4.2	4.5	3.6	6.6	
Operating time (hr)	9.5	11.1	10.4	8.3	8.4	5.4	10.3	7.9	
Fuel consumption (L)									
- 85 Hp-engine motor	6.5	8.0	4.0	3.0	6.0	6.0	5.0	9.0	
- 5 kW light generator	17.0	16.0	15.0	15.0	15.0	13.0	15.0	15.0	
- hydraulic-powered reel	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
Diesel fuel prices (baht/L)	29.99	26.89	26.89	26.09	29.99	26.89	26.89	25.99	
Benzene fuel prices (baht/L)	35.78	28.28	28.28	25.99	35.78	28.28	28.28	28.58	
Total catch (kg)	8.50	4.70	14.36	30.56	19.55	1.01	6.32	6.86	
Revenue from total catch (baht/total catch)	748	324	808	2,714	1,729	48	422	419	
Average prices from total catch (baht/kg)	88.0	68.9	56.3	88.8	88.4	47.5	66.8	61.1	
<i>Operating costs</i>									
Fuel consumption (baht)									
- 85 Hp-engine motor	194.9	215.1	107.5	78.2	179.9	161.3	134.4	233.9	
- 5 kW light generator	509.8	430.2	403.3	391.3	449.8	349.5	403.3	389.8	
- hydraulic-powered reel	35.78	28.28	28.28	25.99	35.78	28.28	28.28	28.58	
Meals onboard (baht)	70.0	60.0	50.0	30.0	60.0	60.0	30.0	60.0	
Ice for bait storage (baht)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	
Total cost (baht)	830.5	753.6	609.1	545.5	745.5	619.1	616.0	732.3	
Net income (baht)	0	0	198.4	2,168.8	983.1	0	0	0	
	(-82.9)	(-429.4)				(-571.5)	(-194.1)	(-313.7)	
Average net income (baht/day)		591.80 (\pm 1,055.48)				245.78 (\pm 491.55)			

Note: Labor cost is not included in the operating cost due to the squid large cast-net fishery in this study is operated as small-scale with no labor.

DISCUSSION

Many people associated with commercial fishing believe that the lunar cycle has an influence on fishing activity and the fishing boat crew know very well the effects due to different moon phases on commercial catches, e.g. the change of the lunar cycle affecting the catch rate of long-line fisheries (Bigelow *et al.*, 1999), squid jigging fisheries (Ulas and Aydin, 2011) and crab gill net fisheries (Mookkaew *et al.*, 2011). Arkronrat and Boutson (2015) reported that squid fishing boat crew believed lunar cycle's effect on the catch rate in squid fishing because of the greatest success during the waning moon phase rather than the waxing moon phase, especially during 12–15th days into a waning moon.

Squid were more easily attracted to the bright lights of the fishing boats when there was no moon light to distract them and this could also improve catch rates. On the other hand, in this study, lunar cycles had no impact on the catch and hence the CPUE and income of this type of fishing under a waxing or waning moon were not significantly different. Thus our results may not give little support to the common belief among the fishing boat crew that catch would be influenced by the phase of the moon. In general, the influence of the lunar cycle on catchability could be due to many different factors, including through its effects on tides, currents, illuminants and squid behavior (Omori, 1995). These alternatives in the case of squid fishing is unfortunately beyond the current data.

The lunar cycle effect explained nearly 30% of the variation in catches. In the case of a nocturnal swordfish fishery, catches were lowest during the full moon phase possibly because of the gill-nets were more visible to the swordfish due to the moonlight (di Natale and Magano, 1995). In contrast, tuna catches by long-lines peaked during the full moon phase. This could occur if these predatory fish were better able to locate the baits in the light provided by the moon (Bigelow *et al.*, 1999). These contrasting effects of moon phase on the catchability of predatory fish illustrate the fact that the effect of moon phase can have varying effects on the catch depending on the nature of the fishery considered. This would

also likely explain the fact that the classification of fisheries into “day” or “night” did not reveal any apparent patterns with respect to moon phase effects (Ortega-Garcia *et al.*, 2008).

In the present study, the results of squid large cast-net fishing under a waxing and waning moon for an average time of operation of 9.8 hr/day and 8.0 hr/day, respectively, showed that the average catch rate (14.53 kg/day and 8.44 kg/day, respectively), the CPUE (1.31 kg/hr and 0.80 kg/hr, respectively) and daily net income (THB 591.80 and THB 245.78, respectively) were rather low. However, the results of Arkronrat and Boutson (2013) and Arkronrat and Oniam (2014) (CPUE was 3.91–4.10 kg/hr; daily income was THB 2,181) contradict the findings from the present study. Variation in the time of operation, geographical variation and fluctuations in environmental parameters may have been the reasons for this variation in the results. Conducting interviews with people involved in squid large cast-net fishing in the Klongwan coastal area, Arkronrat and Boutson (2015) found that most respondents predicted that the future trend for this method of fishing would get worse but they would persist with this career because they had the experience and knowledge with fishing and satisfy in this career. The main problems were decreasing catch size and increasing fishing costs. Similar results for squid fishing in other coastal areas of Thailand have been reported, e.g. in Rayong Bay, Rayong province (Songjitsawat and Sookbuntoeng, 2001), in the Pathew coastal area, Chumphon province (Kaewnuratchadasorn *et al.*, 2003), and in coastal areas of the Andaman Sea (Boonsuk *et al.*, 2010).

Studies on squid fishing using large cast-nets have been very limited. Therefore, the knowledge gained of squid fishing technology was very important and perhaps can be applied to improve the catch and income of squid large cast-net fishing. Yamashita *et al.* (2012) reported that the catch performance of coastal squid jigging boats in the northern waters and western waters of the Sea of Japan was influenced by the number of metal halide lamps, while catches of Japanese common squid (*Todarodes pacificus*) and swordtip squid (*Photololigo edulis*) tended to increase with the number of metal halide lamps. The low power light emitting diode panels (LEDs)

has been a recent focus as a new light source for use as a squid attracting light because of the lower energy consumption (Matsushita *et al.*, 2012; Jeong *et al.*, 2013; Mills *et al.*, 2014). In addition, Arkronrat *et al.* (2014) reported that small-scale squid large cast-net fishing along the Klongwan coast using halogen lamps at different light intensities (300 W, 500 W, 700 W, 900 W and 1,100 W) did not affect the CPUE.

CONCLUSION

In conclusion, the catch rate of target species and non-target species, catch composition, CPUE and income of small-scale squid large cast-net fishing under a waxing and waning moon were not significantly different. It was clear that lunar cycles had no impact on the catch of this fishery. However, analysis associating the lunar cycles with other environmental factors such as wind, currents, and water temperature should be carried out to better understand their influence on squid large cast-net fishing, and to guide energy and cost reductions such as by reducing light intensity and changing the lamp to a light emitting diode (LED), as these are interesting points for future study.

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