Spatial and temporal distribution, Size composition, and Abundance of Oval squid, *Sepioteuthis lessoniana* (Lesson 1830) in the coastal waters of Bolong, Zamboanga City, Philippines

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ABSTRACT

The study was conducted in the coastal waters of Bolong, Zamboanga City, Philippines purposely to determine the spatial distribution of *Sepioteuthis lessoniana* in relation to the depth of water and temporal distribution in relation to lunar phase using size composition and catch per unit effort (CPUE) data. Two sampling stations were established, namely, shallow-water station (Station 1) and deep-water station (Stations 2). Twenty units of squid traps were utilized in the study; ten of which were set in Station 1 and the other ten in Station 2. The traps were constructed using bamboo and green polyethylene netting. Instead of bait, coconut spikelet was placed inside the trap to lure squids. A motorized banca was used to set and haul the traps in the two sampling stations. Although hauling was done daily, sampling is scheduled only 12 times a month with three samplings per lunar phase. Catches were segregated according to sampling stations and lunar phases. Results of the study revealed that the squids caught in deeper waters were significantly larger than those caught in shallow waters, and that females dominated the shallow waters while males dominated the deeper waters. Furthermore, the catch during Full Moon was significantly higher than the catch of the other three lunar phases ($p<0.05$) with highest CPUE recorded in Station 2 during Full Moon (0.352 kg $trap^{-1}$ day^{-1}).

Keywords: Spatial distribution, temporal distribution, squid strap, CPUE

INTRODUCTION

Sepioteuthis lessoniana (Lesson 1830), commonly known as the oval squid or bigfin reef squid, is a commercially important species of loliginid squid. This species of squid preys on live fish and crustaceans. They have eight arms and two tentacles, the latter for capturing prey and guiding it to their sharp beaks. They move by "jet propulsion", sucking water into a muscular sac in the mantle cavity surrounding their bodies and quickly expelling it out a narrow siphon.

Squid together with cuttlefish, octopus, crabs, groupers, ornamental fish, roundscad and sea cucumber constitute the other major fishery exports, contributing 34.5% or US$440 million of the total US$1,268 million export revenues in the Philippines (Philippines Fisheries Profile 2014). Unfortunately, information on catch and distribution of this species are limited and often unavailable. Voss (1963) wrote the first extensive report on the taxonomy of Philippine Cephalopods. Subsequently, Flores (1974) surveyed the traditional fishing grounds and identified some fishing gears and furthermore, Hernando and Flores (1981) described the different squid fishing gears used in the country and contributed information in terms of species identification, fishing seasons, and production. Accordingly, there are four genera and seven species of the squid species in the Philippines with *S. lessoniana* as one of the most common. In the Philippines, *S. lessoniana* is caught mainly by trawl (Hernando and Flores 1981). Regrettably, its contribution to the annual Philippine cephalopod catch of about 10,000 tons (Balgos 1990) is not known, owing to the lack of species-specific data. Few other studies were performed on *Loligo duvauceli* in Indian waters (Chakraborty et al. 1997; Karnik et al. 2003; Meiyappan and Srinath 1989; Mohamed and Rao 1997; Neethiselvan and Venkataramani 2002; Silas et al. 1986).

In the coastal waters of Bolong, catching *S. lessoniana* using squid trap became a very viable source of income for many of the fishermen living in the area. However, despite the importance of this species to the people, very little attention has been done to study the spatial and temporal distribution of this species. There has been one related preliminary study conducted for *S. lessoniana* that is the study of Balgos and Pauly (1998) in Philippine waters. However, spatial and temporal distribution were not clearly defined in that study. In fact, what was stated is that the *S. lessoniana* is an important fisheries species throughout much of its range, from central Japan and the Red Sea in the north, through South and South-East Asia, to Queensland, Australia, and North Island, New Zealand, in the south (Roper et al. 1984).

There are other studies conducted on wild squid populations but on size-at-age between geographical areas (Jackson and Moltschaniwskyj 2002; Chen and Chiu 2003) and between seasonal cohorts (Arkhipkin et al. 2000; Villegas 2001; Pecl 2004). Accordingly, the differences in growth were mainly attributed to the geographical or seasonal prevailing temperatures during the early life stages. Currently, no formal assessment of this resource is undertaken. Some exercises with cohort analysis (Royer et al. 2002; Challier et al. 2006) and depletion methods (Young et al. 2004) have been conducted for loliginid squids, but for the most part, conventional models used in the assessment of finfish stocks are not applicable (Pierce and Guerra, 1994). Nevertheless, if stock size predictions are to rely partly on temperature data (Robin and Denis 1999; Pierce and Boyle 2003; Chen et al. 2006), the understanding of age structure, growth, and its variability under fluctuating environmental conditions is of fundamental relevance.

Hence, the present study was carried out in order to investigate the spatial and temporal distribution of the squid *S. lessoniana* in the coastal waters of Bolong with a view to obtain basic scientific information relevant to management of its fishery. Specifically, the study aims to determine the spatial distribution of *S. lessoniana* in relation to the depth of water and temporal distribution in relation to lunar phase using size composition, CPUE data, and food and feeding habits.

METHODS

Study Site

The study was conducted in the coastal waters of Bolong, approximately 30 km from the Zamboanga City proper (Figure 1). The shoreline in the area was mainly muddy with sandy beach. Two sampling stations were established in the study site. The exact location of the sampling stations was determined using a Global Positioning System (GPS). Station 1 is situated at 07° 03' 45" N and 122° 13' 15" E. Station 2 situated at 07° 01' 15" N and 122° 14' 45" E. The depth of the water in Station 1 ranged from 6 to 10 m, while in Station 2, the water depth ranged from 11 to 15 m.

The estimated area of each sampling station was 2.5 km^2. The substrates of the two sampling stations were mostly muddy and sandy. Based on the interviews with the squid trap operators in the study area, they set their traps in water depths ranging from 6-15 m, and they considered the depths ranging from 6-10 m as shallow waters and 11-15 m as deep waters.

Construction, Setting and Hauling of Squid Traps

Twenty units of squid traps were constructed using bamboo and green polyethylene netting. Instead of bait, coconut spikelet was placed inside the trap to lure squids (Figure 2).

These squid traps, which measure 1.00 m x 0.75 m x 0.60 m, were capable of catching squid particularly oval squid with the use of coconut spikelet as an attractant instead of baits. The squid traps were known to be environment friendly considering that squids caught by this fishing gear were considered marketable in size ranging from 110 mm to 220 mm.

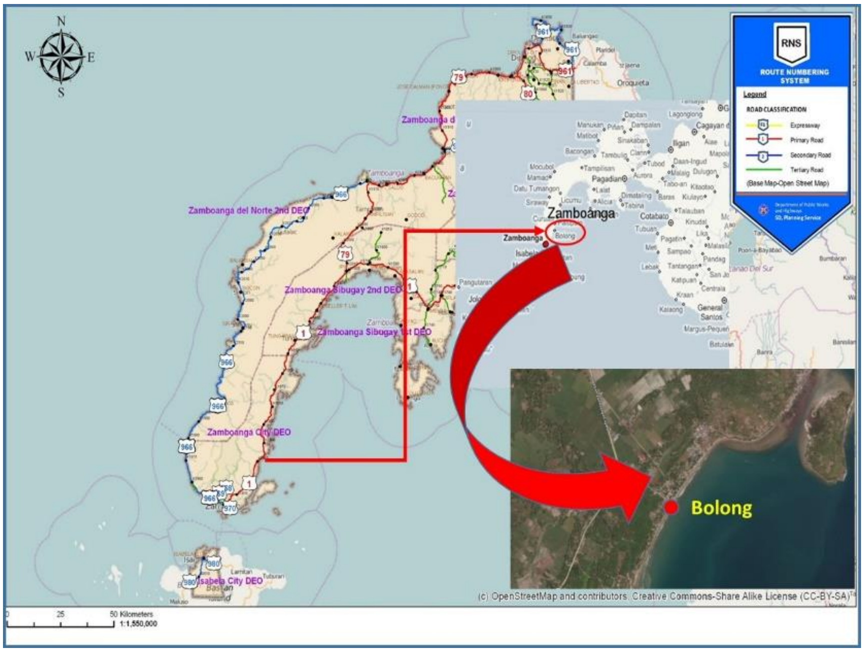

Figure 1. A map showing the location of Bolong, Zamboanga City.

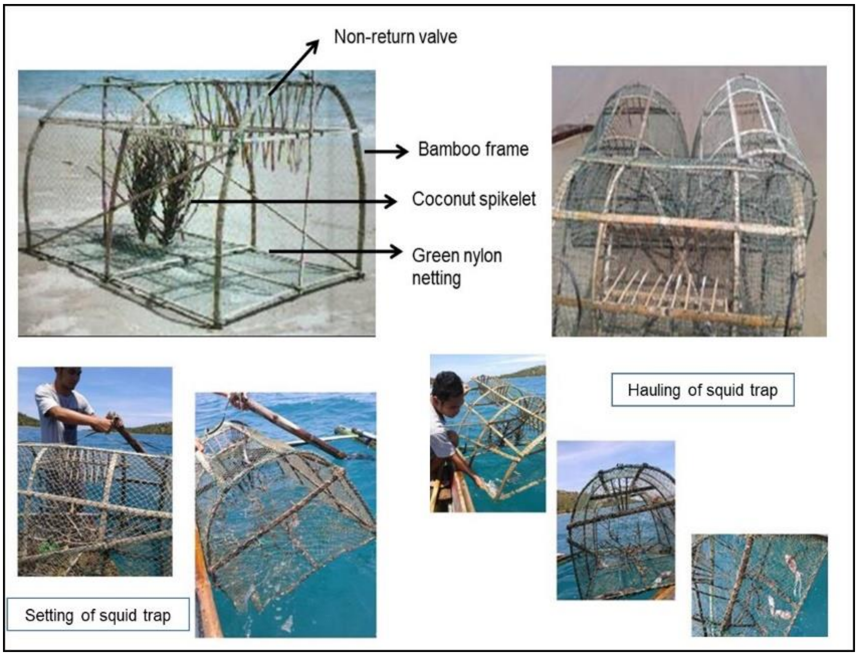

Figure 2. The squid traps used in the study.

Ten traps were set in Station 1 and the other 10 in Station 2. The traps were positioned approximately 1 m away from the bottom. Each trap was attached using a rope to a bamboo pole set perpendicularly to the bottom. The reason why the traps were set 1 m from the bottom was to avoid being covered with mud as the area has a muddy bottom and to avoid being wrapped with algae "lumut". Damaged/lost traps were replaced immediately.

In the shallow water (Station 1), two traps were set starting in 6 m depth, another two were set in the 7 m depth and so forth until the 10 m depth. Likewise, in the deeper waters (Station 2), two traps were set starting at the 11 m depth, two in the 12 m depth and so forth until the 15 m depth. A motorized banca was used to set and haul the traps in the two sampling stations. Hauling is scheduled daily between 0600-0800H.

Field Sampling

Two groups of *S. lessoniana* were sampled. The first group comprises those caught in Station 1 and the other group in Station 2. Although hauling was done daily, sampling was scheduled only 12 times a month with three samplings per lunar phase, i.e., New Moon, First Quarter, Full Moon, and Last Quarter.

Spatial Distribution

Although the traps were set according to specific depth, catches were grouped according to sampling stations. Males were also segregated from the females in both stations. After the segregation, the mantle length and the corresponding weight were measured and recorded. Comparative analysis between the catch (kg) of the oval squid in the two sampling stations was conducted using t-test of independent sample to determine if significant difference exists (Pagano 2004).

Temporal Distribution

In order to determine the temporal distribution, the catch data were grouped according to lunar phase, i.e., New Moon, First Quarter, Full Moon, and Last Quarter. Comparative analysis was conducted according to lunar phase using Analysis of Variance (ANOVA) to determine if significant differences exist. Post hoc analysis was also done using Duncan Multiple Range Test (Duncan 1955).

Catch-per-unit-effort (CPUE)

Catch data collected (including effort) on a weekly basis were grouped on a monthly basis. Catch-per-unit-effort (CPUE) was determined following the equation:

$$\text{CPUE} = \frac{\text{Total catch (kg)}}{\text{No. of gear units x day}}$$

In a study conducted by Chen et al. (2002), squid catch was compiled in a geographically referenced format using a statistical grid of 0.5° (0.5°longitude by 0.5°latitude). The catch per unit effort (CPUE, t/vessel/d) of squid was standardized using a relative CPUE comparison method (Salthaug and Godø 2001). Then the adjusted CPUE was used as an index of squid abundances to illustrate the spatiotemporal patterns of population dynamics. In this study, however, this model was not adopted due to limited information in time and space.

RESULTS

Spatial Distribution

Three hundred thirty-two (332) individuals of *S. lessoniana* were caught using squid traps in the coastal waters of Bolong from August to October 2017 with a total weight of 134.94 kg (Table 1). The total catch recorded in Station 1 was 55.88 kg (41.41%) and the total catch in Station 2 was 79.06 kg (58.59%). While higher catch of female squid was recorded in Station 1 (31.01 kg) as compared to the males (24.87 kg), higher catch of males was recorded in Station 2 (45.81 kg) as compared to the females (33.25 kg).

Table 1. Monthly catch of male and female *S. lessoniana* by sampling station (M - male; F - female).

Months (2017)	Monthly Catch (kg)						
	Station 1			Station 2			Pooled
	M	F	Total	M	F	Total	
Aug	8.92	10.05	18.97	14.74	11.05	25.79	44.76
Sep	8.34	11.60	19.94	14.96	10.89	25.85	45.79
Oct	7.61	9.36	16.97	16.11	11.31	27.42	44.39
Total	24.87	31.01	55.88	45.81	33.25	79.06	134.94

Temporal Distribution

The catch of *S. lessoniana* relative to the different phases of the moon is shown in Table 2. Full Moon registered the highest catch (51.80 kg) with mean weight of 492.60 g. New moon recorded the second highest catch (34.43 kg), with mean weight of 412.99 g. First Quarter was third with 26.76 kg with mean weight of 350.19 g. The lowest catch happened in the Last Quarter (21.97 kg), with mean weight of 307.14 g.

Table 2. Monthly catches (kg) and mean body weights (g) of *S. lessoniana* by lunar phase in 2017.

Lunar Phases	Monthly Catches (kg)			Total (kg)	Mean Body Weight (g)
	Aug	Sep	Oct		
First Quarter	8.29	8.88	9.59	26.76	350.19
Full Moon	18.06	16.84	16.88	51.78	492.60
Last Quarter	7.00	8.39	6.58	21.97	307.14
New Moon	11.41	11.68	11.34	34.43	412.99
Total	44.76	45.79	44.39	134.94	Ave: 390.73

Duncan's Multiple Range Test (DMRT) reveal significant difference among the mean weights of the four different lunar phases with p value less than 0.05 (Table 3).

Table 3. DMRT among moon phases in terms of mean weights of *S. lessoniana*. Note: All means having the same letter are not significant at α=0.05

Moon Phases	Mean Weight (g)	Notation
Full Moon	492.60	a
New Moon	412.99	b
First Quarter	350.19	c
Last Quarter	307.14	c

Further analysis reveal that significant difference exists between the mean weights of squid caught during Full Moon (492.60 g) against the other three moon phases. Significant difference also exists between the mean weights of squid caught during New Moon (412.99 g) and the other two moon phases (First and Last Quarter) whose mean weights are 350.19 g and 307.14 g, respectively. No significant difference, however, exists between the First and Last Quarter (p>.05).

Size Composition

The mean mantle length of *S. lessoniana* was recorded at 194.29 mm with 73% of the squid in the range 110-240 mm. The males registered a mean mantle length of 192.52 mm and females 196.54 mm, with 76% of the male within the length ranges of 110-240 mm and the females within 160-220 mm.

The mean weight of *S. lessoniana* for all stations was 405.99 g with males registering a mean weight of 397.14 g and females 416.16 g. August registered a mean weight of 382.62 g, September with 407.37 g, and October with 431.02 g. In Station 1, the males registered a mean weight of 304.78 g while the females recorded 382.95 g. In Station 2, the males registered a mean weight of 436.31 g while the females recorded 455.53 g. Although the total catch of male squids in Station 2 was higher than the females, the female squids were bigger than the males in both Stations 1 and 2 (Figure 3).

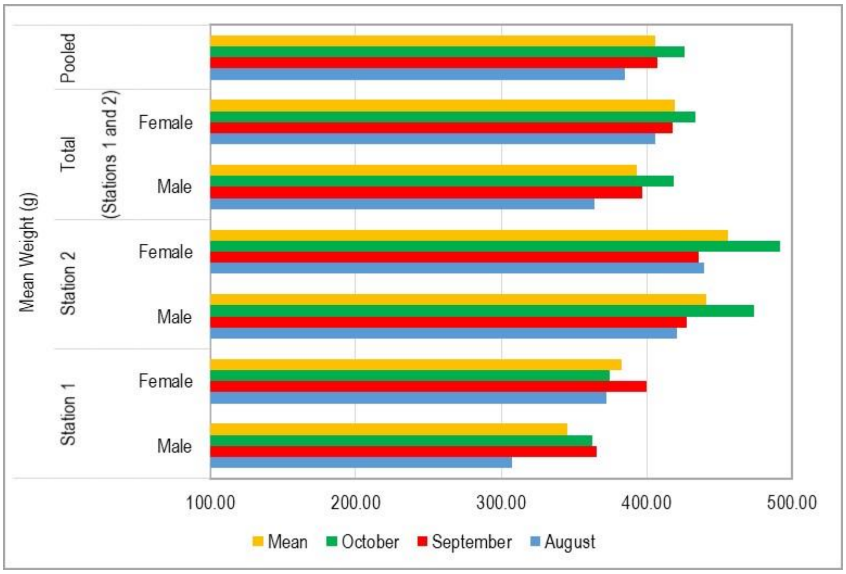

Figure 3. Monthly mean weight (g) distribution of *S. lessoniana* by sampling station.

Abundance

The abundance of oval squid was analyzed in terms of the catch-per-unit-effort (CPUE). The CPUE for the two sampling stations was recorded at 0.188 kg $trap^{-1}$ day^{-1}, with the highest monthly CPUE recorded in Station 2 in the month of October with a mean CPUE of 0.229 kg $trap^{-1}$ day^{-1}, while the lowest was recorded in Station 1 of the same month with 0.155 kg $trap^{-1}$ day^{-1}.

Furthermore, results of the mean catch-per-unit-effort (CPUE) according to the four different moon phases reveal that the highest CPUE was recorded in Station 2 during Full Moon (0.352 kg trap^{-1} day^{-1}) and the lowest was recorded in Station 1 during First and Last Quarters with 0.107 kg trap^{-1} day^{-1} and 0.110 kg trap^{-1} day^{-1}, respectively (Figure 6). The results further showed the highest CPUEs were recorded during Full Moon in both sampling stations, and lowest CPUEs were recorded during the Last Quarter in both sampling stations.

DISCUSSION

There is a possibility that the 3-month data obtained in this study (August-October) will be the same if conducted in other months considering that *S. lessoniana* are abundantly found in the area year round as claimed by the fishermen. The results where the findings reveal that female squids are abundantly found in the shallow waters concur with the findings of Segawa (1987). The reason behind this is female squids prefer shallow waters with twigs and other rough surfaces where they can easily attach their egg capsules. This justifies why in this study, male squids were abundantly found in the deeper waters (Station 1) as compared to females, which is contrary to the observation made by Segawa (1987) in Kominato and adjacent waters of central Honshu, Japan, where the females dominated the males.

The findings of the study on the mantle length of *S. lessoniana* in this study also concur with the findings reported in the study by Sivashanthini et al. (2009) in Jaffna lagoon, Sri Lanka. In the present study, the mean mantle length of *S. lessoniana* was recorded at 194.29 mm with 73% of the squid in the range 110-240 mm. The males registered a mean mantle length of 192.52 mm and females 196.54 mm, with 76% of the male within the length ranges of 110-240 mm and the females within 160-220 mm. In the length-weight relationship conducted by Sivashanthini et al. (2009), the size of the mantle length of *S. lessoniana* ranged from 38-255 mm with mean mantle length of 137.30 mm. The mantle length of males ranged from 55-255 mm with mean mantle length of 138.90 mm. The mantle length of females ranged from 38-248 mm with mean mantle length of 135.80 mm. Although in the present study the female squids are significantly bigger than the male squids, no significant difference exists in the study of Sivashanthini et al. (2009) despite of same result where the females *S. lessoniana* are bigger than the males.

The dominance of female oval squids in Station 1 is a manifestation that female *S. lessoniana* prefer shallow waters where there are twigs and other objects for them to attach their egg capsules. Segawa et al. (1993) also made the same observation in in Ishigaki Island, Okinawa, southwestern Japan. His findings show that female *S. lessoniana* are abundantly found in shallow waters where they lay their eggs in *Sargassum* beds. In the study of Chen et al. (2006), time-series maps of squid abundances against the background of sea surface temperature (SST) for the same period were created to visually analyze and depict spatial and temporal patterns of squid abundances, and changes in abundances relative to changes in SST. Spatial correlations between squid abundances and SST were calculated using Spearman's rank correlation for the monthly grid data set. Furthermore, a time series analysis was applied to investigate the temporal autocorrelations of environmental variables.

Sepioteuthis lessoniana can lay eggs year round but the major spawning season may vary according to location. Spawning may occur as early as January in warmer waters, while in cooler waters near Japan, spawning can begin as late as September. Females lay their eggs in single straight strands on rocks, corals, plants, submerged branches, and other surfaces along shorelines. After laying eggs, the body of the female usually deteriorates and dies before she can mate again (Segawa et al. 1993) On the other hand, the male can usually mate with several more females before he dies (Sivashanthini et al. 2009; Ikeda et al. 2009; Jereb and Roper 2006; Wada et al. 2005). This explains the dominance of female *S. lessoniana* in the shallow waters (Station 1) and the dominance of males in the deeper waters as observed in the present study. Hence, the spatial distribution of female *S. lessoniana* is comparatively higher in the shallow waters while the spatial distribution of the males is higher in the deeper waters.

It has also been observed that higher catch and bigger squids were recorded during Full Moon with 51.78 kg and 492.60 g, respectively. It has also been observed that the highest mean CPUEs were recorded during Full Moon (0.288 kg $trap^{-1}$ day^{-1}) and New Moon (0.191 kg $trap^{-1}$ day^{-1}). These findings may imply that the temporal distribution of *S. lessoniana* is higher during Full Moon and New Moon.

In general, oval squids were abundantly found in the deeper waters of Bolong, Zamboanga City during Full Moon and lowest in the shallow waters during the First and Last Quarter. Specifically, however, female oval squid preferred shallow waters where they can easily attach their egg capsules during spawning. Furthermore, significant difference exists between the mean weight of oval squid in the deeper waters and shallow waters. Significant difference also exists among moon phases, with Full Moon registering the highest mean weight. Moreover, field observations revealed that oval squid forms the most important fishery in the coastal waters of Bolong, Zamboanga City. Hence, catching oval squid became a viable source of income for many of the fishermen living in the area.

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