Biomass and distribution of the red octopus (*Octopus maya*) in the northeast of the Campeche Bank

Journal:	*Journal of the Marine Biological Association of the United Kingdom*
Manuscript ID	JMBA-01-19-OA-0016.R1
Manuscript Type:	Original Article
Date Submitted by the Author:	22-Mar-2019
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Keywords:	Octopus maya, Red octopus, Spatial, Density, Abundance, Continental shelf, Yucatán
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Abstract

The regulatory framework of the red octopus (*Octopus maya*) fishery includes total allowable catches (TAC), which are based on studies conducted on the population that occurs in shallow waters. In fact, most of the biological studies of this species refer to the fraction of the population that occupies waters less than 30 m deep; however, *O. maya* can occur up to a 60 m depth. The aim of this study is to assess the stock of *O. maya* that occupies waters between 30 m and 60 m deep. Four research cruises were carried out during the closed and fishing seasons, from May 2016 to January 2017. An average of 29 sampling sites were surveyed in each cruise (± 2 sampling sites) using a commercial vessel with a uniform sampling effort. In each sampling site, the swept area, the total number of octopuses captured, the total weight of the catch, and the individual weight of octopuses were recorded. Biomass was obtained with four methods: stratified random method, swept area method, geo-statistical biomass model, and an unpublished method of weighted swept area. The four methods provided consistent results. The distribution pattern of species was in patches, although before the fishing season started it was more homogeneous. The fraction of the population that occurs between 30 m and 60 m deep consisted mostly of adult organisms, so it could be contributing significantly to the recruitment of the entire population, even to the fraction that is exploited.

Key words: *Octopus maya***,** Red octopus, spatial, density, abundance, continental shelf, Yucatán.

Introduction

The octopus stocks that occupy the western and northern coasts of Yucatan Peninsula are considered by far one of the most important resources for small-scale fishers from Mexico due to its high productivity, economic value and international demand (Cabrera-Vázquez *et al.*, 2012). Records show that two species are exploited namely red octopus, *Octopus maya,* Voss & Solís-Ramírez, 1966 and the common octopus, *O. "vulgaris"* type I (Cuvier, 1797; Jereb et al., 2014). However, new studies suggest that the latter corresponds to *O. insularis* (Lima *et al.*, 2017).

O. maya contributes more than 60% to the fishing production of octopus in the region (Velázquez-Abunader *et al.*, 2013). It is an endemic species of the continental shelf of the Yucatan Peninsula. Although it has been observed to be abundant both in shallow (< 30 m) and deeper waters (up to 60 m), but more abundant in shallow waters (DOF, 2016). The species displays a heterogeneous distribution, having the greatest abundance in the coasts in front of the State of Campeche, predominantly composed of small individuals, while the largest individuals are found in front of the State of Yucatan (Cabrera-Vázquez *et al.*, 2012; Gamboa-Álvarez *et al.*, 2015). A more recent study suggests that perhaps two closely related sub-stocks of *O. maya* exist in the region: the first occupies the western coast of the Yucatan Peninsula, where reproduction exhibits a clear seasonality with a peak during the winter and, a second stock located at the north of the Yucatan peninsula, where spawners can be found all year round (Ángeles-González *et al.*, 2017).

The most recent stock assessment indicates that *O. maya* is exploited at the "maximum level" (i.e. close to the maximum sustainable yield) with annual landings of more than 10,000 tones (Jurado-Molina, 2010). In order to maintain production levels, the authority established the minimum legal size of 11 cm mantle length, a closed fishing season (from January to July), and total allowable catch (TAC). The TAC is obtained from biomass estimations using surplus production models based on the catch landings reports (DOF, 2016).

Octopus maya is captured by two fleets: a small-scale fleet (boats of 5 to 12 m length) that operates in shallow waters (up to 20 m depth) and a medium-scale fleet (boats from 15 to 25 m length) that operates in areas deeper than 20 m. Both fleets use small boats 4 m in length (locally known as "alijos") which are drifted by the currents to catch octopus (Salas *et al.*, 2008). These fleets use the same fishing gears and operate in different fishing grounds but sometimes overlap due to the accessibility and high abundance of the resource in those areas (Salas *et al.*, 2008; Gamboa-Álvarez *et al.*, 2015). Likewise, as a result of easy access and low monitoring costs, most of the studies on biology and stock assessment for *O. maya* refers to animals found in the shallow waters of those fishing grounds (<30 m) (Cabrera-Vázquez *et al.*, 2012; Velázquez-Abunader *et al.*, 2013; Avila-Poveda *et al.*, 2016; Ángeles-González *et al.*, 2017; Duarte *et al.*, 2018), however, producing a dearth of information on the fraction of the population that occupies areas from 30 m to 60 m depth. The private sector of Mexico has expressed its intention to expand the fishing grounds for the medium-scale fleet to deeper waters in view to its economic importance (DOF, 2016). It is for that reason that the objective of this study is to evaluate the available biomass of *O. maya* and learn more about its distribution in coastal areas in the Campeche Bank where the depth is between 30 m and 60 m, to provide basic information for its management.

Material and methods

Study area

The study area, known as the Campeche Bank, is located in the coastal zone at the northeast of the Yucatan Peninsula, between 30 m and 60 m depth (Figure 1). The area is strongly influenced by the Yucatan current, which produces a stationary upwelling, from May to September, but there is vertical mixing during winter due to strong north winds from 70 km h^{-1} to more than 100 km h^{-1} (from October to January) (Enriquez *et al.*, 2010; Salas-Pérez *et al.*, 2012). The average temperature is 20° C but and a range of 17° C to 30° C. The upwelling enhances the concentration of nutrients resulting in a high biological productivity.

Field work

Four research cruise ships independent of the fishery were conducted from May 2016 to January 2017. Each cruise was made on board of a vessel of the medium-scale fleet with landing port in Progreso, Yucatan. An average of 29 (± 2) sampling sites were surveyed per cruise ship; the distance between sampling sites was 28 km in May-June, and 14 km in the other cruises (Figure 1). Sampling sites were systematically aligned in the study area, using *spsample* function of *sp* package (Pebesma & Bivand, 2005) of the programming language R (R Core Team, 2017). During the season closed for fishing, two cruises were carried out, May-June 2016 and July 2016, just when the fishing seasons started. Two additional cruises were placed on December 2016 and January 2017, to represent the end of the fishing season.

The survey and collection of organisms were done through regular fishing operations. The vessel was a mother ship of five “alijos” (4 m length); each carrying two rustic poles made of bamboo of approximately 8 m length, one in the bow and other in the stern of the boat. Each pole had 2 nylon lines tied with fishes (*Diplectrum sp* and *Haemulon sp.*) as bait, which were dragged at the sea floor as the boat drifted at sea (Jurado-Molina, 2010; Velázquez-Abunader *et al.*, 2013; Gamboa-Álvarez *et al.*, 2015; Markaida *et al.*, 2017). Each “alijo” had a global positioning system (GPS) to track the course and thus measure the swept area. The initial and final times were recorded to standardize the effective fishing effort in three hours and the sampling effort in five "alijos" per sampling site per day. In each sampling site, the total number of octopuses captured (N_t), the total weight of the catch (TW) and the individual weight of octopuses (W_i) were recorded.

Area of influence of sampling sites

In order to have a better approach to the potential area of influence of each sampling site, Thiessen (or Voroni) polygons were deployed (Brassel & Reif, 1979), to calculate the area of each polygon and, finally, obtain the representative area of each sampling site in relation to the total sample area. Thiessen polygons and the area of each polygon were calculated with the ArcMap 9.2 software (Sawatzky *et al.*, 2009).

Biomass assessment

Four methods were used to calculate the *O. maya* biomass per research cruise: stratified random method (Cochran, 1980; Scheaffer *et al.*, 1987), swept area method (Pierce & Guerra, 1994), geo-statistical biomass model (Rivoirard *et al.*, 2008), and an unpublished method of weighted swept area, whose advantage is that it does not assume *a priori* homogeneous distribution of the resource in the whole area, as the traditional swept area method does (Pierce & Guerra, 1994).

The stratified random method uses the frequencies distribution of total weight of the catch, which is classified by strata (Cochran, 1980). This method requires to calculate the number of strata (expressed in kg) by means of the Sturges rule (Nevárez-Martínez *et al.*, 2000) which calculates the number of intervals of the catch, starting from the minimum and maximum catches recorded in each cruise. Equations to calculate biomass were the following. The average counting (expressed in kg) in the i^{th} stratum ($\bar{y}_i$) was:

$$\bar{y}_i = \frac{1}{N}\sum^{i} y_{ji} \quad (1)$$

The variance estimator for $\bar{y}_i$:

$$\hat{V}(\bar{y}_i) = s_i^2 = \frac{1}{N_i}\sum_{j=1}^{L}(y_{ji} - \bar{y}_i)^2 \quad (2)$$

The estimator of the total size of the population expressed in kg:

$$N\bar{y}_{st} = \sum_{i=1}^{L} N_i \bar{y}_i \quad (3)$$

The variance estimator for the total population size $\hat{V}(N\bar{y}_{st})$:

$$\hat{V}(N\bar{y}_{st}) = \sum_{i=1}^{L} N_i^2 \left(\frac{N_i - n_i}{N_i}\right)\left(\frac{S_i^2}{n_i}\right) \quad (4)$$

The confidence interval (p = 0.95) for the population size:

$$N\bar{y}_{st} \pm 2\sqrt{\sum_{i=1}^{L} N_i^2 \left(\frac{N_i - n_i}{N_i}\right)\left(\frac{S_i^2}{n_i}\right)} \quad (5)$$

where N_i is the total number of sampled units (km^2) in the i^{th} stratum, L is the number of strata, n_i is the number of sampling units (km^2) in the i^{th} stratum, y_i is the average weight in the i^{th} stratum, and S_i^2 is the variance of the counting in the i^{th} stratum.

The swept area method considers the catch in weight (biomass) obtained from the area swept by the “alijos”, assuming a homogeneous distribution of the resource in the study zone, with a single estimate for the whole area sampled.

Total biomass (B_T) was calculated with the next equation (Pierce & Guerra, 1994):

$$B_T = \sum_{i=1}^{n}\left(Y_t \frac{A_t}{a_t}\right) \quad (6)$$

with variance:

$$\hat{V}(B_T) = \sum_{i=1}^{n}\left(\frac{A_t^2 m_t S_t^2}{a_t^2}\right) \quad (7)$$

where Y_t is the total catch in the study area, A_t is the total area of study, a_t is the cumulated area swept of the five “alijos”, S_t^2 is the variance of the total catch in the study area, m_t is the number of fishing trials and $\hat{V}(B_T)$ is the variance of the total biomass. In this case, a_i represented the area swept by the i^{th} “alijo”. Therefore, the total swept area a_t (expressed in km^2) for each fishing trial was calculated as:

$$a_t = \sum_{i=1}^{5} a_i \quad (8)$$

a_i was calculated with the following equation:

$$a_i = D_i \times LJ_i \quad (9)$$

where D_i is the distance traveled by the i^{th} “alijo”, obtained from the track recorded by the GPS and LJ_i is the length between the extreme tips of the i^{th} “alijo´s” bamboo poles ($LJ_i = 8$ m). Finally, total abundance (N_T) for each cruise ship was calculated with the equation:

$$N_T = \frac{B_T}{TW} \quad (10)$$

where $\overline{TW}$ is the average weight of the octopus as obtained from the biological sampling. For the estimation of B_T the assumptions were the same as for the swept area method (details of the method are contained in Csirke 1989).

In order to estimate the biomass using the geo-statistical biomass model, we proceeded to calculate the catch per unit of area (CPUA, expressed in number of octopuses per km^2), obtained by dividing the number of octopuses captured by the corresponding area at each sampling site. The spatial correlation of CPUA was calculated by means of omnidirectional empiric variograms, which measures the correlation between the variance generated by all the differences of the data pairs separated by a distance previously established, with that distance (h) (Hernández-Flores *et al.*, 2015). Thereafter, a kriging interpolation technique was applied to obtain the densities throughout the interpolation nodes between the neighboring values (Cressie, 1992) and produce a spatial structure that depends on the spatial arrangement of the population (Webster & Oliver, 2007).

The empirical variograms were obtained with the equation:

$$\gamma(h) = \frac{1}{2N(h)}\sum_{i=1}^{N(h)}[C(x_i) - C(x_i + h)]^2 \qquad (11)$$

where $\gamma(h)$ is the variance for h distance, $N(h)$ is the number of paired observations separated by distance h, $C(x_i)$ is the CPUA observed at site x_i and $C(x_i + h)$ is the CPUA observed at any another site separated h distance from site x_i. The obtained interpolations were divided into CPUA intervals, obtaining an average value for the i^{th} interval ($\overline{CPUA_i}$). The total abundance of the i^{th} interval (Ni) was obtained from multiplying the ($\overline{CPUA_i}$) by total area covered by the i^{th} interval, so the total abundance (N_T) was obtained with the equation:

$$N_T = \sum_{i=1}^{n} \overline{CPUA}_i \times A_i \qquad (12)$$

and the biomass was obtained with the equation:

$$B_T = N_T\overline{TW} \qquad (13)$$

The weighted swept area method, proposed in this study, consisted in analyzing the catches registered by the five "alijos" that operated at every i^{th} sampling site (a_i) as the only datum for that site. The total biomass was obtained by adding the individual biomass estimated in each sampling site. Thus, the biomass was obtained with the next equation:

$$B_T = \sum_{i=1}^{n} Y_i\left(\frac{A_i}{a_i}\right) \qquad (14)$$

With standard deviation:

$$\widehat{SD}(B_T) = \sqrt{\sum(Y_i - \overline{Y})^2}\ \left(\frac{A_i}{a_i}\right) \qquad (15)$$

where Y_i is the total catch in the i^{th} stratum, Y is the average catch in the study area, A_i is the total area in the i^{th} stratum, a_i is the swept area in that stratum and $\widehat{SD}(B_T)$ is the standard deviation of total biomass. Abundance was again calculated with equation 10.

For the interpretation of the weighted swept area method, it was necessary to modify the assumption of densities homogeneity, so the total catch Y_i of the distribution area A_i was specific for every sampling site. Another assumption was that each "alijo" had the same probability of catching the octopus at a fixed radius of action such that the sampling effort could be extrapolated to a constant area a. The swept area is considered as the area covered by each "alijo" drifting at each sampling site. Finally, within the area, each unit of sampling effort has the efficiency to catch octopuses every moment only a fraction of the population.

Spatial distribution pattern

To describe the type of pattern distribution of *O. maya*, the equation proposed by Guerra (1981) was modified. The average probability of octopus presence per sampling site was estimated, as well as the type of distribution. Then, the parameters p and k of the negative binomial distribution were estimated.

$$P(x/k) = \left(\frac{k(k+1)(k+2)\ldots(k+x-1)}{x!}\right)p^x q^k \quad (16)$$

To demonstrate if octopus's distribution was random (i.e. homogeneous in the study area) or if it formed patches (i.e. aggregate in some places), a simple random distribution was created assuming the negative binomial distribution. According to this method, the estimation of the parameter of the negative binomial distribution (k) could be: $K_1 = \bar{x}^2/S^2 - \bar{x}$, testing some of the following conditions: if $\bar{x}$ value was low, then $K/\bar{x} > 6$, if $\bar{x}$ was high then $K > 13$, and if $\bar{x}$ value was moderate then $\left(\frac{(k+\bar{x})(k+2)}{\bar{x}}\right) \geq 15$.

If none of these conditions occurs, K_1 is inadequate then, it is calculated with:

$$K_2 \log_{10}\left(1 + \frac{\bar{x}}{K_2}\right) = \log_{10}\left(\frac{N}{f_0}\right) \quad (17)$$

in any case, $p = \bar{x}/K$ (19)

Once the parameters were calculated, to verify if the distribution was in patch, a goodness-of-fit test was applied between the distribution function of the total sample and the theoretical negative binomial distribution (Zar, 1999).

Results

Biomass

The coefficient of variation (CV) for the biomass obtained with the four methods was lower for the cruise ship of May-June (CV = 0.12) and higher for January (CV = 0.26). The areas of influence for each sampling site determined by the Thiessen polygons ranged from 60 to 940 km^2 with an average of 242 km^2. The lower biomass was calculated for the cruise ship of May-June (47.3 ± 6.8 t), while the highest was estimated for December (141.22 ± 12.7 t) (Table 1). Of the four models, the geo-statistical biomass model consistently resulted in the lowest values in the four cruise ships, while the other three methods produced results more alike. This is so because geostatistic analysis assumes a heterogeneous distribution pattern generated by the parameters of the semivariogram, through which the minimum size of each pixel is calculated. On the other hand, the other methods extrapolate the average values of biomass to units of areas wider than those of the geostatistical model. The precision of the geostatistic method will depend on how well it represents the real spatial distribution of the abundance within a reduced coverage relative to the other methods. The geo-statistical biomass model estimations were between 22 % and 47% lower than that of the other models (Table 1). Similar pattern was observed for densities; however, the increases from one month to the next were not as marked as in biomass. The highest densities were recorded in the cruise ships of May-June and July 2016 (13.4 and 20.5 octopus km^2, respectively), while the lowest densities were observed in the cruise ships of May-June 2016 and January 2017 (7.6 and 10.3 octopus km^2, respectively). Similarly, the geo-statistical biomass model resulted in the lowest values of density in the four cruise ships and the weighted swept area method produced the highest values (Table 1).

Distribution

The value of the parameters *p* and *k* ($k_2 = 2$, $p = 0.5$) of the negative binomial distribution showed that *O. maya* presented a patchy distribution (Figure 2), suggesting that the abundance increases according to distance in an area specific and then begins to decrease at higher distances. This is plausible if we consider that the study area deepens as the latitude increases. So, in the shallower water the abundance increases.

The cruises made before the fishing season (May-June and July 2016) recorded the highest densities and abundances in the south and southwest of the study area (Figure 3). The octopuses displayed a heterogenous distribution throughout the study area with lower CPUE overall in the cruises carried out at the end of the fishing season (December 2016 and January 2017); nevertheless, areas of aggregation continued appearing in the analysis, although with lower densities than in May-June and July of 2016 (Figure 3).

Discussion

Many cephalopod fisheries are managed through total allowable catches, which are usually based on the evaluation of the biomass before the start of each fishing season (Nevárez-Martínez *et al.*, 2000). This is the case of *O. maya*, although frequently the TAC is exceeded in some seasons (Jurado-Molina, 2010). This is mainly due to their reproductive strategies that in many cases are semelparous, as well as their short longevity and rapid growth. These biological characteristics make the structure of populations to consist of intra-annual cohorts that are replaced year after year (Hernández-Herrera *et al.*, 1998; Arreguín-Sánchez *et al.*, 2000). That is why it is important to calculate the biomass of exploited cephalopods at different moments during the fishing season, since this will reveal the stock size, recruitment periods and the time when the biomass increases (i.e. stock reduction analysis and proportional escapement analysis) (Rosenberg *et al.*, 1990).

This was the first study to determine the biomass and distribution of the *O. maya* carried out in the north eastern zone of the Campeche Bank between 30 m and 60 m depth. Most techniques to calculate biomass use catch and fishing effort data, which are not always available as is in the case of *O. maya* fishery. However, this study used a systematic sampling design, independent of the fishery, which has the advantage of covering a larger distribution area, controlling the sampling effort (Pierce & Guerra, 1994; Hernández-Flores *et al.*, 2015).

Given that there are no previous studies on the biomass of octopus for the fraction of the population that occurs more than 30 m deep in the study area, this study used four methods to analyse the data, with particular characteristics and assumptions. Our results show that differences in the biomass estimates from each of the four methods (CV < 26.5% per cruise) could be biologically relevant and important consideration for managers (Pierce & Guerra, 1994). These differences in the results could be related to factors such as the distribution pattern of the resource and the sampling design; for example, in the swept area method, the weighted swept area method and the geo-statistical biomass method, the distance between sampling sites is key so as not to exceed the area of extrapolation per sampling site, while in the stratified method the number of intervals is key in the estimate. It is instructive to apply the Sturges rule from the start of the analysis (Labastida, 1991). The assumption of heterogeneous distribution of the resource is perfectly applicable to the benthic organisms that remain in the same habitat as long as the conditions are favourable, and that present a patchy distribution, such as was the case of *O. maya*.

In resources such as the jumbo squid from the Gulf of California, biomass has been calculated through the stratified random method and the swept area method, showing significant differences in the results of both (Nevárez-Martínez *et al.*, 2000). These discrepancies were attributed to the type of stratification used in each method, since the randomized method stratified the catch data, while the swept area method stratified the data spatially (Nevárez-Martínez *et al.*, 2000). Therefore, in addition to the method, it is important that fisheries managed with total allowable catches apply the precautionary approach considering the most conservative result (Nevárez-Martínez *et al.*, 2000), which in the case of the *O. maya* should be applied when estimating in the fishing grounds. This precautionary approach should be applied in the areas with the greatest fishing effort.

The distribution of the *O. maya* has not been thoroughly studied; most studies have covered the immediately coastal zone with the highest concentration of octopuses between 0 and 30 m depth. Some studies have suggested that the *O. maya* has a heterogeneous distribution in the shallow waters of the Campeche Bank (< 30 m depth) (Solís-Ramírez & Chávez, 1986; Gamboa-Álvarez *et a.,* 2015) as a response to changes in the environment like the effect of the wind during winter or the type of substratum. Cephalopods are organisms highly sensitive to environmental changes, so they can carry out active migrations in search of favourable conditions to continue their life cycle (Pierce *et al.*, 2008). In this study, although in general, *O. maya* showed a patchy distribution, during the December and January cruises it was more randomly, with few aggregations of low CPUA values. This type of distribution has been reported by Gamboa-Álvarez *et al.* (2015) in the shallow waters of the Yucatan Peninsula, probably due to the dynamics of the ocean in the region that includes significant changes in temperature (Enriquez *et al.*, 2010), which is a key factor for the biological processes of the species (Ángeles-González *et al.*, 2017). In this sense, it has been reported that *O. maya* has a low capacity to adapt to high variations of temperature, producing a significant negative impact on its survival rate and abundance (Noyola *et al.*, 2013). As shown by Hermosilla *et al.* (2011), there is a negative correlation between sea bottom temperature and abundance of *O. vulgaris* in the Mediterranean Sea. In consequence, temperature changes limit octopus distribution in deeper waters, which seems to be the origin of the distribution observed in this study.

As occurs in other cephalopods like inshore squids and some octopod species including the common octopus (*O. vulgaris*), *O. maya* shows a great plasticity in its life cycle, which gives it a great ability to adapt to the prevailing conditions where it lives (Pecl and Jackson 2008; Ramos *et al.,* 2008; Otero *et al.,* 2009), but there are no studies that correlate environmental variables with the biomass and distribution of *O. maya*. Therefore, it seems that the home range of this species should be well specified, which could be a priority for future research. However, spatial differences in population structure of this species have been evaluated. Authors such as Velázquez-Abunader *et al.* (2013) indicated that the landings of the medium-scale fleet (which fishes in deeper waters than the small-scale fleet) were mainly composed of large organisms, so that the stratum of the population that occurs in deeper waters could be composed mostly of mature individuals of the spawning stock. Thus, this fraction of the stock could contribute significantly to the recruitment of the entire population, even to the fraction that is currently exploited (< 30 m depth), so it is suggested to avoid the exploitation of this resource in deeper areas. In addition, the methods used in this study could be applied to calculate the biomass in the most intense fishing areas, as long as a stratified sampling design is applied. Therefore, future work should make an assessment of the biomass and distribution of *O. maya* in shallower fishing areas.

Acknowledgment

The authors thank to the Federación de Sociedades Cooperativas de la Industria Pesquera del Centro y Oeste del estado de Yucatán, SC de RL for the logistical support and with the boat to carry out the cruises. To Jesús Miguel Soto Vázquez for his support in the field work. Thanks are also due to Mr. Babatunde O. Musa for proofreading.

Financial support

The results of this study were obtained as part of the project Distribución, reproducción, biomasa y patrones de movimiento del pulpo común *Octopus vulgaris* Cuvier, 1797 en la costa de Yucatán with financial support of the Consejo Nacional de Ciencia y Tecnología (grant number 237057).

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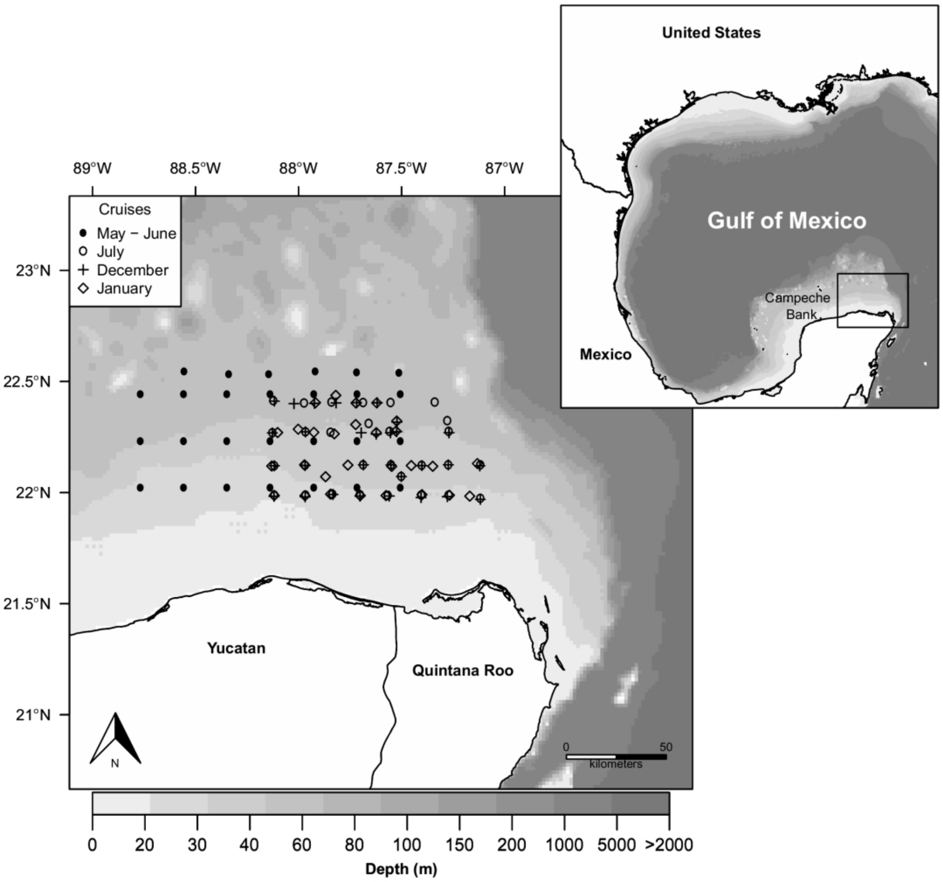
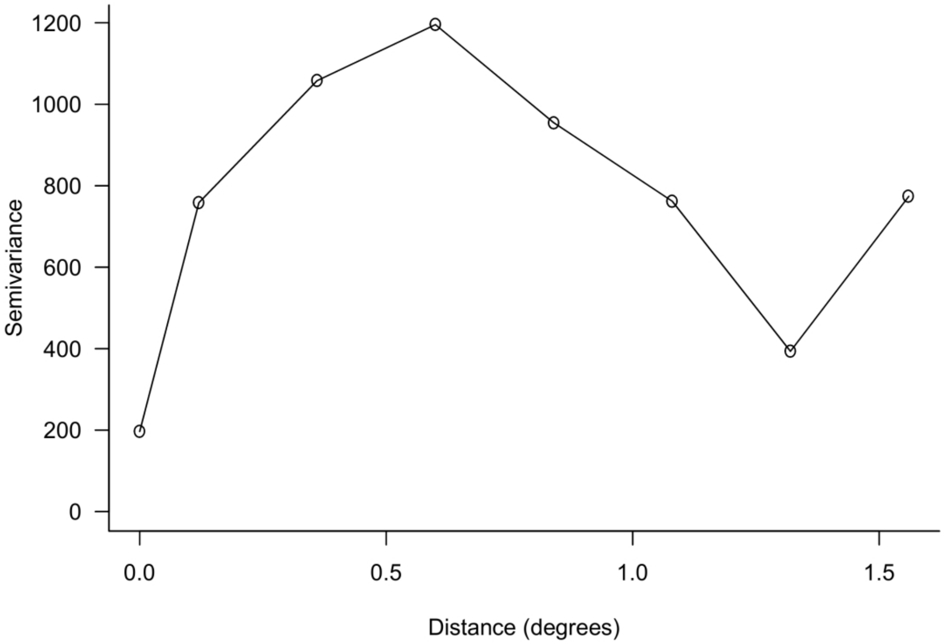


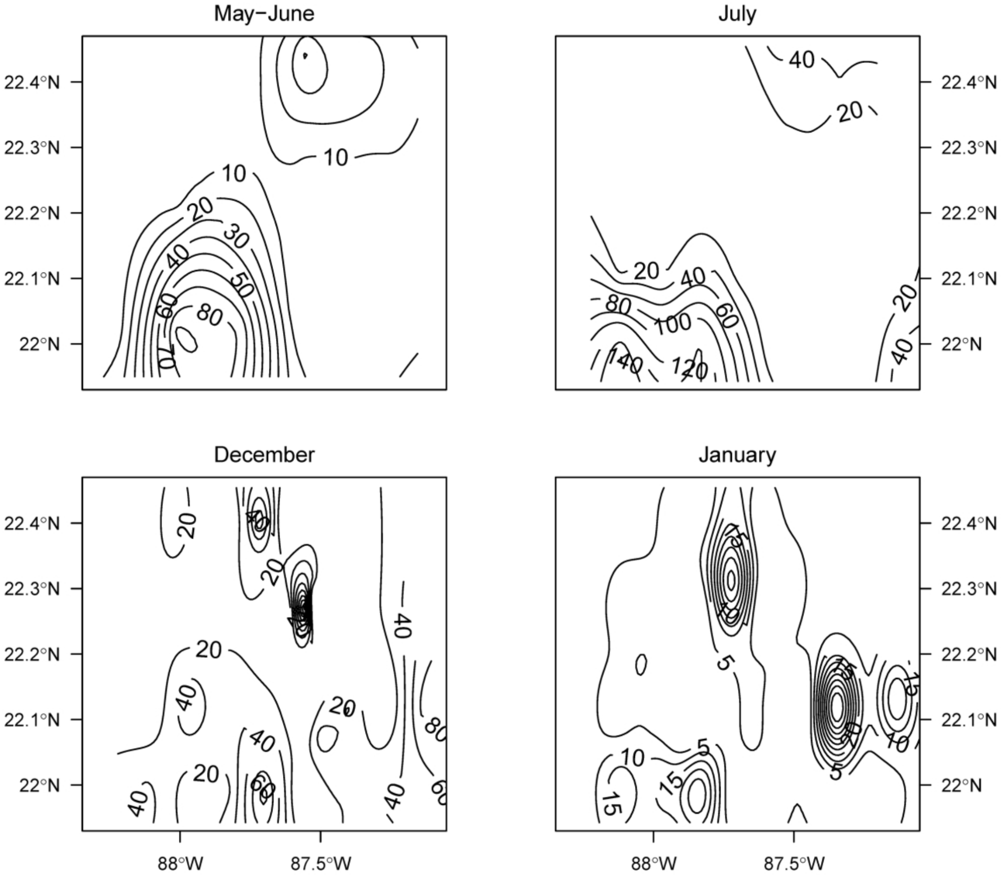
Study area for fishing of the Red octopus (*Octopus maya*) to the East of Campeche Bank, Mexico.

182x173mm (300 x 300 DPI)



Semivariogram analysis of the abundances (CPUA; Org./km^2) of the Red octopus (*Octopus maya*) in the north eastern Campeche Bank, Mexico. The behavior indicated a grouped type distribution

185x144mm (300 x 300 DPI)



Spatiotemporal distribution of the Catch Per Unit Area (CPUA: Org./km^2) of the Red octopus (*Octopus maya*) in the north eastern Campeche Bank, Mexico

192x168mm (300 x 300 DPI)

Table 1. Estimated values of the biomass per cruise ± standard error (SE) and the density ± standard error (SE) of the Red octopus (*Octopus maya*) in the north eastern Campeche Bank. The biomasses were standardized to a total area of 5000 km^2. CV: coefficient of variation of the estimates by cruise of the four methods.

Method	**Biomass (tonnes)**	**± SE**	**Density (Org./km^2)**	**± SE**
May-June 2016	CV = 12.5%		CV = 12.5%	
Stratified	47.7	1.0	9.5	0.2
Swept area	50.0	8.8	9.7	1.7
Geostatistic	39.0	8.6	7.6	1.6
Weighted	52.8	9.0	10.3	1.7
July 2016	CV = 18.3%		CV = 17.7%	
Stratified	103.2	0.9	19.8	0.2
Swept area	94.8	12.5	18.4	2.4
Geostatistic	68.3	12.5	13.4	2.4
Weighted	105.6	15.3	20.5	2.9
December 2017	CV = 19.3%		CV = 19.5%	
Stratified	149.5	14.1	22.5	2.1
Swept area	161.1	13.7	24.0	2.0
Geostatistic	100.8	10.4	15.0	1.5
Weighted	153.4	12.6	22.9	1.9
January 2017	CV = 26.3%		CV = 25.4%	
Stratified	71.1	14.5	10.2	2.0
Swept area	70.0	9.9	9.5	1.4
Geostatistic	37.7	9.6	5.4	1.3
Weighted	70.9	11.2	9.6	1.5