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Article

Biological aspects of *Lutjanus peru* in Bufadero Bay, Michoacán, México: growth, reproduction and condition factors

Aspectos biológicos de *Lutjanus peru* en Bahía Bufadero, Michoacán, México: crecimiento, reproducción y factores de condición

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Resumen.- Se estudian algunos aspectos biológicos de *Lutjanus peru* (Pisces: Lutjanidae) recolectado en la Bahía Bufadero, Michoacán, México. El análisis de escamas permitió identificar cuatro anillos de crecimiento, valores similares fueron obtenidos por medio de los estimadores de densidad de Kernel. Los resultados de la ecuación de crecimiento de von Bertalanffy obtenidos por el método lineal simple fueron: L_∞= 81,12 cm, W_∞ = 4.839 g, K= 0,24 años^{-1} y t_o = -0,39 años. Los máximos valores del índice de repleción y del factor de condición ocurren durante los meses de febrero, abril y junio. Los periodos de máxima reproducción ocurren durante los meses de febrero y agosto. Los periodos de reclutamiento al área son de enero a julio para los nacidos en agosto, y de agosto a diciembre para los nacidos en febrero. El tamaño de reclutamiento al arte de pesca es de 18 cm. El índice gonadosomático muestra una relación inversamente proporcional en relación al índice hepatosomático. La longitud corporal de *L. peru* en su primera madurez sexual es de 25,45 cm y su longevidad es de 12 años. El 65,84% de la pesca en Bahía Bufadero es de organismos sexualmente inmaduros, por lo que se propone como talla mínima de captura una longitud de 45 cm (edad 3 años) y un periodo de veda para agosto y septiembre.

Palabras clave: Lutjanidae, determinación de la edad, escamas, índice hepatosomático, índice gonadosomático

Abstract.- Some biological aspects of *Lutjanus peru* (Pisces: Lutjanidae) collected from Bufadero Bay in Michoacán, Mexico, were analyzed. Scale analysis allowed determining four growth rings. Similar data were obtained with an indirect method (Kernel density estimates). Results of von Bertalanffy's growth equation obtained by simple linear method were: L_∞= 81.12 cm, W_∞= 4,839 g, K= 0.24 years^{-1} and t_o = -0.39 years. The maximum values of the repletion index and condition factor occurred during February, April and June. Spawning peaks occurred between February and August. Recruitment periods in the area were from January to July for those born in August, and August to December for the ones born in February. Recruitment length of the fishing gear is 18 cm which occurs after age one. The gonadosomatic index is inversely proportional to the hepatosomatic index. Length of first sexual maturity is 25.45 cm. Longevity of *L. peru* is estimated to be at least 12 years. In Bufadero Bay, 65.84% of the catch is on sexually immature organisms, therefore we suggest that fishing captures should consider specimens larger than 45 cm (age 3 years) and a closed season for August and September.

Key words: Lutjanidae, age determination, scales, hepatosomatic index, gonadosomatic index

Introduction

The Pacific red snapper *Lutjanus peru* (Nichols & Murphy, 1922) (Pisces: Lutjanidae) is distributed throughout tropical and subtropical regions, from the Gulf of California to Peru (Allen 1985). This species is demersal inhabiting coastal waters around rocky bottoms and reefs, from 30 to 100 m in depth (Arellano *et al.* 2001). During juvenile stages, *L. peru* lives in estuaries and river mouths forming schools. Once it reaches adulthood it migrates to small coves or cavities to live in solitary or in small groups (Sheaves 1995, Madrid & Sánchez 1997, Allen & Robertson 1998, Arellano *et al.* 2001, Piñón 2003). Its abundance is influenced by sea surface temperature (SST) and decreases during the "El Niño" years (Madrid & Sánchez 1997).

This species has an increase activity at dusk (Arellano *et al.* 2001) due to its carnivorous and opportunistic feeding habits mainly of crabs, prawns, squid, jellyfish and small sized fishes (Rojas *et al.* 2004a). In tropical areas, where climatic variations are lower than cold and template zones, the spawning and recruitment periods last longer, as in the case of *Lutjanus peru* in the coast of Manzanillo, two periods yearly including several months each (Espino-Barr 1996).

This species presents an asynchronic reproduction and is a partial spawner with reproductive activity throughout the year (Arellano *et al.* 2001). Reproductive patterns seem to depend on the size of the population and its distribution along the continental margin (Grimes 1987). Rojas-Herrera (2001) determined the size of first sexual maturation for this species at 29.5 cm furcal length and a male:female proportion of 1:1.37. Espino-Barr (1996) established February as the month of maximum reproduction, and when the growth ring is formed on scales, as a result of changes in the fish's condition factor, off the coast of Colima, Mexico.

Chiappa-Carrara *et al.* (2004) observed that recruitment periods do not coincide in time and space for *Lutjanus peru* and *L. guttatus* off Guerrero's coast, which can be understood as a phenomenon to lessen interspecific competence and help both species coexist. Espino-Barr *et al.* (1998) estimated growth parameters using von Bertalanffy's (1938) equation for *L. peru* along the coast of Colima, Mexico from 1982 to 1997. They documented similar parameters over time, suggesting stability in the population of this species. Fishing assessments of the catch made by Rojo-Vásquez *et al.* (1999) reported that the selection medium length of 29.1 cm was obtained with 3" mesh size gillnet and 33.9 cm with 3.5" mesh size gillnet. Cruz-Romero *et al.* (2000) considered that to protect the existing biomass in Colima, the catch of *L. peru* should not exceed 150 tonnes. Díaz-Uribe *et al.* (2004) considered that a fishery regulation is needed on the age or size of first capture of *L. peru* in the southeast Gulf of California, to avoid overfishing. Ramos-Cruz (2001) suggested a size of minimum capture of 31 cm total length and a maximum fishing mortality of $F = 0.52$ in the coastal zone of Salina Cruz, Mexico.

Total fishery landings of lutjanids in Mexico have increased from 1982 to 2002, ranging between 4,000 (1983) and 11,617 ton (1993) with an average of 7,500 tonnes per year. The state of Michoacán had the sixth highest annual landings of lutjanids in 2005 (305 ton) (Espino-Barr *et al.* 2006).

It is important to study the population dynamics and life-history characteristics of the Pacific red snapper to be used in assessing stock status and fishery exploitation with the aim of preventing overfishing of this resource. This study has original information on age, growth, longevity, period of reproduction, length of first capture, recruitment, condition factor, gonadosomatic and hepatosomatic indexes of *Lutjanus peru* along the coast of Michoacán.

Material and methods

Commercial fishery of Bufadero Bay, Michoacán (18º04'24"N, 102º45'18"W) (Fig. 1) was sampled bimonthly during 5 day periods from August 2005 to June 2006. A total of 1,016 individuals were collected. These were measured for total (TL; cm) and standard length (SL; cm), height (H; cm) and total (TW; g) and eviscerated (EW; g) weight. Liver, gonad and stomach were weighed *in situ*, preserved in 10% formalin prepared in sea water. Sex was determined for 347 individuals; the other 668 were immature specimens.

Scales, were collected from behind of pectoral fins of 803 individuals for age analysis. The sample size was calculated with the formula described by Daniel (1991). About 10 scales were taken from an area under the left pectoral fin, below the lateral line (Ruiz-Durá *et al.* 1970, Holden & Raitt 1975, Ehrhardt 1981) and stored in dry labeled envelopes. Following the method described by Holden & Raitt (1975), the scales were washed to clean them and to remove any tissue stuck to them. Four scales were then placed between two microscope slides, sealed with adhesive tape and labeled. Reading of the scales was carried out with the help of a Kodak Ektagraphic transparency projector with a 127 mm lens (which increases the size of the scale 13.4 times). Scales were measured from the focus to the farthest border as their length and between the longest lateral borders for their width. Growth rings in the scales were counted independently by two different observers. When their results were different, the sample was analyzed again.

Determination of the marginal increment (MI) was carried out according to Lai & Liu (1979) to determine the date in which the growth ring is formed and to validate the periodicity. The equation is: MI= (R-rn)/(rn-rn-1), where R = scale's radio, rn = center to last scale's ring distance, rn-1= center to one before last scale's ring distance.

To compare and validate the scale readings, indirect methods were used: Bhattacharya's (1967) and Kernel density estimates (KDE), to determine components

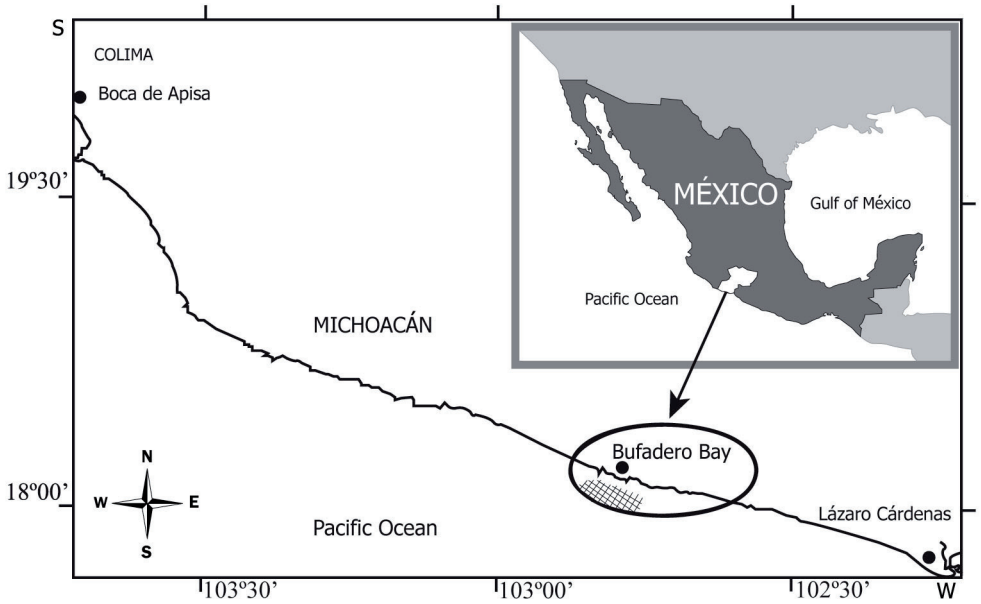

Figure 1. Map of study site / Mapa de la zona de estudio

of the polymodal curve (Salgado-Ugarte 1992, 2002). To specify the suitable bandwidth, Silverman's (1981) smoothed bootstrap method was used with routines of Stata 9.0 proposed by Salgado-Ugarte *et al.* (2005), which suggests a number of modes in each sampling month with a significant value. Later a KDE was obtained for each sampling month to determine the length classes and their temporal distribution.

The growth constants L_∞ (asymptotic length), K (catabolic index) and t_o (organisms age at 0 length) of von Bertalanffy´s (vB) equation were obtained with the methods of Ford (1933), Walford (1946), Gulland (1964) and Beverton & Holt (1959) and two types of regression: simple non linear vB equation and weighted non-linear vB equation (Salgado-Ugarte *et al.* 2005).

Weight-length relationship was calculated with the function $W = a * L^b$ (Mendenhall 1987, Zar 1996), liberalized ln-ln transformation and calculated by least squares. The weight for every age was obtained with the growth data in length and the weight-length function. Weight growth was obtained substituting TL and L_∞ for TW and W_∞, in vB equation.

Gastric repletion state was classified according to Gallardo-Cabello & Gual-Frau (1984) as: GRI = number of full stomachs / total number of stomachs. The gonadosomatic index (GSI) was determined with the equation described by Rodríguez-Gutiérrez (1992): GSI= GW/TW*100, where: GW = gonad weight and TW = total weight of the individual. The hepatosomatic index (HSI) was calculated according to Rodríguez-Gutiérrez (1992) as HSI = LW/TW *100, where: LW = liver weight and TW = total weight of the individual. Two condition factors were used: eviscerated weight (Clark 1928) and total weight (Fulton 1902). Gonadic maturity index was determined *in situ*, according to Nikolsky (1963).

Size of first maturity was obtained by the logistic method (Salgado-Ugarte *et al.* 2005), which fits the sexually mature individuals proportion (P) in relation to TL: $P = 1/[1+\exp(-r(TL-Lm))]$, where: r = trend of the curve; Lm = mean length of 50% mature females.

Age limit or longevity $A_{0.95}$ (95% of L_∞) was determined mathematically with Taylor´s equation (1958, 1960): $A_{0.95} = \ln(1-0.95)/ K + t_o$. And the growth evaluation index, phi prime (Pauly 1991) was used to compare growth curves obtained by different authors: $\Phi' = \text{Log}_{10} K + 2*\text{Log}_{10} L_\infty$, where K = growth coefficient and L_∞= asymptotic length.

Results

Average total length (TL) of *Lutjanus peru* was 27.13 cm, which corresponds to a maximum body height of 8.41 cm and 315 g. Length ranged 18.0-61.50 cm, and height of 4.50-18.50 cm. Weight ranged 70-2370 g. The relation between TL and standard length (SL) showed an isometric growth with a slope $b = 0.94$ ($P < 0.001$). Also the relationship between TL and height (H) was isometric, with trend $b = 0.81$, indicating the relationship between TL

and height of the organism persists as its age increases ($P < 0.001$). Total weight (TW) and TL relation has a slope value of $b = 2.82$, indicating an isometric relation in which the organism increases its weight proportionally to its length ($P < 0.001$).

The regression scale between length and width indicates an isometric relation with slope $b = 1.057$ ($t = 3.114$, $P < 0.001$). There is a direct positive relationship between TL and scale length $b = 1.009$ ($t = 35.33$, $P < 0.001$), which makes scales a suitable structure to estimate size of fish (length) for this species. During the sampling months, the ring formation was observed in February (0.8 ± 0.54 mm), suggesting that one ring is formed every year. Analysis of scales identified 4 age groups. The percentage of scales showing perfectly defined growth rings was 98%; only 2% showed regenerated scales. The values obtained with KDE (indirect method) for ages 1 to 4, were: 23.94, 36.94, 44.37 and 57.21 cm respectively, showing small differences compared with results obtained with scale readings.

Table 1 shows the values of von Bertalanffy´s equation constants calculated by three methods: Ford-Walford, Gulland, Beverton & Holt, Simple non linear vB equation and weighted non linear vB equation: The constants were similar among the methods applied. Nevertheless the nonlinear method provides the best correlation and fits statistically better to the observed data: $L_\infty = 81.12$ cm, $K = 0.24$ yr-1 and $t_o = -0.390$ years ($X^2 = 0.99$, df = 6, $\alpha = 0.05$). The longevity of *L. peru* was determined as 12 years old.

Average length values for each age were: 23.19 cm for age one, 35.64 cm for age two, 45.41 cm for age three and 53.09 cm for age four. Annual instant growth rate in length was 12.45 cm from ages one to two, 9.78 cm from two to three and 7.67 cm from age three to four. Calculated total weight was 142 g for age one, 474 g for age two, 943 g for age three and 1464 g for age four. The growth curves for observed and calculated values of length and weight for *L. peru* is shown in Fig.2.

Values of von Bertalanffy's growth constants and Pauly's (1987) growth index (ϕ') for *L. peru* from the Mexican Pacific coast by different studies, including the present study are shown in Table 2. The $\phi' = 3.20$ were within the confidence range for the growth evaluation index.

The increment of condition factor (CF) was observed in February, April and June according to Fulton index, and in April and June according to Clark index. The CF relates to the maximum values of the Gastric repletion index GRI (Table 3). The highest values of the gonadosomatic index (GSI) were in August and February. With exception of August, values of this index corresponded to the lower monthly values of the hepatosomatic index (HSI) and *vice versa* (Table 3).

The main spawning period of *L. peru* takes place during August, and a second period during February. Length of first sexual maturity of *L. peru* was 25.45 cm (TL) equivalent to 1 year old (Fig. 3).

Discussion

The semi-rectangular ctenoidea scales of this species are considered suitable to determine age and growth as mentioned by Castro (1981), Madrid (1990), Espino-Barr (1996) and Sarabia (2005). The ring used to determine age is formed in February, which coincides with the one observed by Espino-Barr (1996). This ring is formed due to several factors, such as low temperature, changes in the fish condition factor and reproduction activity. It is important to mark that because of these factors, with or in addition to horizontal distribution and bathymetric migrations, also "false rings" are formed on the scales that can be recognized because they are not complete around the scale or because they are not formed by several aggregated lines, with a density that does not allow the light to go by, which one as a dark band (Joseph 1962).

Distance between growth rings diminishes as age increases, which is in agreement with the fact that rate of accumulation of structural components on the scale has an inverse relation over time (Arellano *et al.* 2001). This way the growth of scale is related to the fish length. Faster growth takes place during the first stages of life before sexual maturity of this fish, after this event the

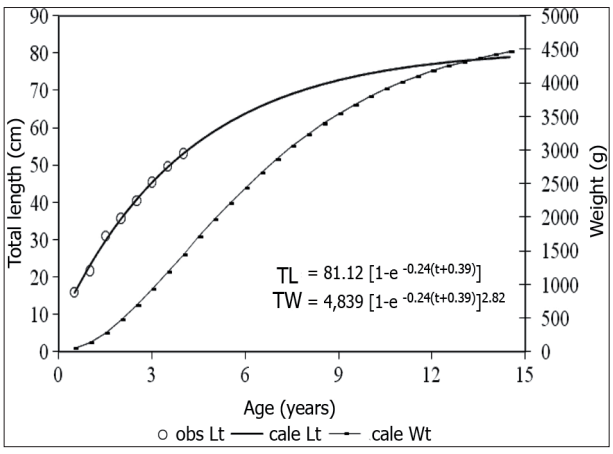

Figure 2. Growth curve in length and weight with von Bertalanffy's equation for *L. peru* / Curva de crecimiento en longitud y peso con la ecuación de von Bertalanffy para *L. peru*

Table 1. Growth parameters determined by different methods for *Lutjanus peru* / Parámetros de crecimiento de *Lutjanus peru* por diferentes métodos

Parameters	Ford-Walford	Gulland	Beverton & Holt	Simple non linear vB equation	Weighted non linear vB equation
a	9.145	9.145	4.303		
b	0.887	-0.113	-0.121		
r^2	0.986	0.528	0.997	1.000	0.999
Fitted R^2	0.983	0.434	0.996	0.999	0.999
L_∞	81.24	81.24	81.24	81.12	83.07
K	0.119	0.119	0.121	0.242	0.118
t_o			-0.783	-0.391	-0.725

Note: a and b = parameters of the lineal fitting to age data; r^2 = determination index; L_∞; K and t_o = growth parameters

Table 2. Growth parameters of *Lutjanus peru*, calculated by various authors in different areas of the Mexican Pacific. (S=scales; O= Otoliths; F= Length frequency; SL= Standard length; TL= Total length) / Parámetros de crecimiento de *Lutjanus peru* obtenidos por varios autores en diferentes áreas del Pacífico mexicano. (S=escamas; O= otolitos; F= frecuencia de tallas; SL= longitud estándar; TL= longitud total)

Study area	Reference	Method	L_∞ (cm)	K (1/year)	t_o (year)	Longevity	ϕ'	Length
B.C.S.	Castro (1981)	S	66.71	0.232	0.540	13	3.01	TL
La Paz, B.C.S.	Rocha & Muñoz (1991)[1]	O	90.80	0.130	-0.033	23	3.03	TL
Barra de Navidad to Punta Pérula, Jal.	González-Ochoa (1997)	O	70.50	0.090	0.500	34	2.65	SL
Jalisco	Espino-Barr *et al.* (2006)	F	121.79	0.143	-0.042	21	3.33	TL
Colima	Cruz-Romero *et al.* (1996)	F	81.73	0.156	0.029	19	2.81	TL
Colima	Espino-Barr *et al.* (1998)	F	69.72	0.130	-0.020	23	2.80	TL
		S	79.43	0.100	-0.030	30	2.80	TL
Colima	Espino-Barr *et al.* (2006)	F	72.42	0.130	0.006	23	2.83	TL
Michoacán	Ruiz-Luna *et al.* (1985)	S and F	80.50	0.190	0.756	17	3.09	TL
Michoacán	Madrid (1990)	S	81.50	0.190	0.786	17	3.10	TL
Michoacán	Hernández-Montaño *et al.* (2002)	F	95.33	0.180	-0.750	16	3.21	TL
Michoacán, Guerrero & Oaxaca	Aguilar (1986)	S	85.02	0.110	-1.570	26	2.90	TL
Michoacán	This paper	S	81.12	0.240	-0.390	12	3.20	TL
Guerrero	Rojas-Herrera (2001)	O	92.51	0.092	-1.663	31	2.90	TL
Guerrero	Rojas Herrera (2001)	F	80.00	0.138	-0.669	21	2.90	TL
Guerrero	Cabrera- Mancilla & Gutiérrez-Zavala (2004)	F	77.00	0.084	-2.532	33	2.70	TL
Guerrero	Santamaría & Chávez (1999)	F	80.80	0.140	0.230	22	2.96	TL
Oaxaca	Ramos-Cruz (1996)	F	61.80	0,153	-0.303	19	3.31	TL

Modified from Espino-Barr *et al*. (2006)

[1] Rocha OA & VM Muñoz. 1991. Relación entre el crecimiento individual y el de los otolitos del huachinango *Lutjanus peru* (Nichols y Murphy, 1922) en la Bahía de la Paz, B.C.S. p. 28. Resúmenes del II Congreso Nacional de Ictiología. S. Nicolás de los Garza, N.L., México.

growth index of the scale and fish tends to be slow and make themselves asymptotic (Gallardo-Cabello & Gual-Frau 1984). Mean length data obtained by scale readings are very similar to those obtained by KDE method, which validates both methods: growth rings identification on hard structures and age groups with polymodal curves analysis.

The relationship between TL and TW in Bufadero Bay, Michoacán, varied monthly mainly because weight was affected by factors such as season, age, food, spawning season, sexual and gonadic maturity (Cushing 1975, Margalef 1989). The asymptotic length value of *Lutjanus peru* determined in this study was 81.12 cm and the maximum length observed was 61.50 cm. This was comparable with Chirichigno *et al.* (1982) reporting 50 cm mean length in the Central and South oriental Pacific coast. However, other studies have reported maximum TL of 95 cm (Fischer *et al.* 1995), and other between 91 and 97 cm for Colima and Jalisco, respectively (Espino-Barr *et al.* 2003, 2004). It is important to mention that age determination by von Bertalanffy's equation is an average of lengths and it displays a dispersal range within the growth (Salgado-Ugarte *et al.* 2005); for this reason organisms of greater longevity may be considered within this dispersion or unusual events of growth, combined with the fact that as populations are closer to the equator the infinite length (L_∞) tends to be smaller and therefore its growth coefficient (K) higher (Taylor 1958). *L. peru* populations in areas closer to the equator and living in warmer waters reach smaller average lengths at each age, and populations in northern areas that ones that reach higher fishing yields by the increase of the captured biomass.

The nonlinear parameters of the growth equation were accepted based on additional statistical information such as confidence intervals, t student values and parameters significance, in addition to reduction of deviations by minimum square analysis (Salgado-Ugarte *et al.* 2005). According to Sparre & Venema (1995) the nonlinear regression by this analysis is superior to any other procedure from a theoretical and statistical point of view.

Discrepancies found between growth parameters for this species in different areas are due, among other reasons, to the sampling type, method and length used to determine the value of constants, season and latitude where these studies were carried out. Nevertheless, these differences are compensated with the evaluation of the growth index, which shows similar values between populations of the same species or near taxa (Sparre & Venema 1995).

Biologically, annual trends of the relation between TL and TW, show that the gain in weight is low before it reaches maturity because the entire energy of the organism is used to increase its length and diminish natural mortality (Cushing 1975). Once it reaches the first sexual maturity, weight gain increases due to reproduction requirements (gonad weight and fat storage), combined with young fish migration towards adult areas. These results have differences in weight according to the quality and amount of food consumed (Allen 1985, Sheaves 1995, Madrid & Sánchez 1997, Gallardo-Cabello *et al*. 2007, Espino-Barr *et al.* 2008). In the present paper the more active feeding periods, represented by values of gastric repletion (GRI) correspond to months of spring and summer, when the availability of food is higher due to a higher temperature and photoperiod. GRI lowers during August due to the reproductive period and increments again during October, the restoration period for the spawning population.

The condition factor that better reflected the quality of the habitat and therefore the food availability was the one

Table 3. Summary of the condition factor (CF), gastric repletion (GRI), gonadosomatic index (GSI) and hepatosomatic index (HSI) of *Lutjanus peru* / Resumen de los índices del factor de condición (CF), repleción gástrica (GRI), gonadosomático (GSI) y hepatosomático (HSI) de *Lutjanus peru*

Month	CF Fulton	CF Clark	GRI	GSI	HSI
Aug-05	1.04	0.90	0.45	6.24	3.14
Oct-05	1.19	0.72	0.75	0.23	0.97
Feb-06	1.37	0.83	0.58	1.22	0.50
Apr-06	1.41	1.15	0.81	0.24	0.96
Jun-06	1.21	1.11	1.00	0.21	0.87
n	1,016	1,016	1,016	347	347

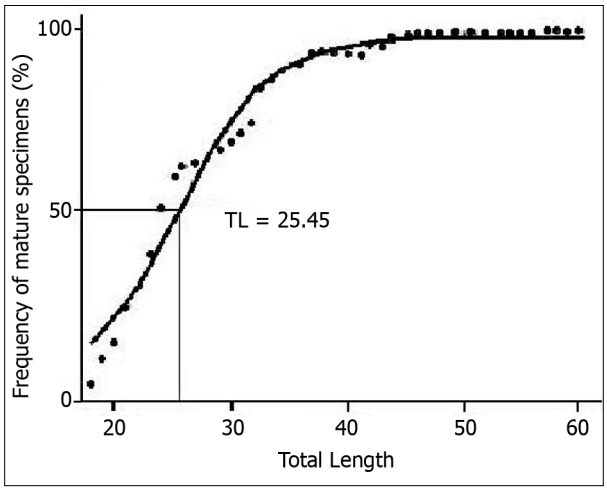

Figure 3. Logistic curve of sexual maturity of *L. peru* / Curva logística de la madurez sexual de *L. peru*

proposed by Gallardo & Gual Frau (1984) with the use of the eviscerated weight which allowed eliminating the interference of the gonadic and liver development. These values of CF showed a delay of two months with respect to the gastric repletion index as a reaction of catabolism carried out in nutrient assimilation (Salgado-Ugarte *et al.* 2005). However, these two parameters keep a close inverse relation (in the case of GSI and GRI) and direct relation in the case of CF and HSI as mentioned by Rocha & Muñoz (1993) for *Lutjanus peru* in the Bay of La Paz.

The spawning season estimated in this study (August) agrees with reports of different authors for Colima, Michoacán, Guerrero and Oaxaca, although with exception to Espino-Barr *et al.* (2006) (Table 4). Pacific red snapper born in August will recruit to the fishing area during January to July; those born in February will be recruited to the area from August to December. These individuals will grow for another two years before they are fully recruited by the fishing gear. At 18 cm and age group one, organisms of *Lutjanus peru* are first captured.

Minimum length of first sexual maturity for females in this study was 25.45 cm TL. Similar values in this study area were found by Ruiz-Luna *et al.* (1985) and Ruiz (1983), who reported sexually mature red snappers in the state of Michoacán of 28.8 cm. Also Rojas *et al.* (2004b) calculated first sexual maturity length at 29 cm TL, but in the state of Guerrero. Higher values were calculated by Santamaría *et al.* (2003) who reported the beginning of the first sexual maturity at 35-40 cm TL. Cruz-Romero *et al.* (2000) found in Colima a length at first maturity at 28 and 33 cm TL for males and females, respectively. Although there are variations in the length at first maturity, *L. peru* usually reaches it before three years of age (Ruiz 1983,

Table 4. Spawning period of *L. peru* in different states of the Mexican Pacific / Periodo de reproducción de *L. peru* en diferentes estados del Pacífico mexicano

Spawning period	State on the Mexican Pacific	Reference
November to April	Baja California Sur	Ochoa *et al.* (1991)[2]
May to June and November to December	Jalisco	Espino-Barr *et al.* (2006)
January to March and August to September	Colima	Cruz-Romero *et al.* (1991)
March to June and November to December	Colima	Espino-Barr *et al.* (2006)
End of May and middle of November	Michoacán	Madrid (1990)
April and September	Michoacán	Ruiz *et al.* (1982)
August	Michoacán	Present paper
April and September	Michoacán, Guerrero y Oaxaca	Ruiz (1983)
April and September	Michoacán, Guerrero y Oaxaca	Aguilar (1986)
March to May and September to December	Guerrero	Rojas-Herrera (2001)
April-May and July-September	Guerrero	Rojas-Herrera *et al*. (2000)[3]

[2]Ochoa BRS, G Garcia & R Martínez. 1991. La actividad reproductiva de *Lutjanus peru* (Perciformes: Lutjanidae) en las costas de San José del Cabo, B.C.S. p.40, Resúmenes del II Congreso Nacional de Ictiología, Sn. Nicolás de las Garzas, N.L., México

[3]Rojas-Herrera AA, A Santamaría & JF Elorduy. 2000. Desarrollo gonádico y época de desove del huachinango (*Lutjanus peru*) (Nichols y Murphy, 1922) (Lutjanidae: Perciformes) en la costa de Guerrero, México. Programa y resúmenes del XII Congreso Nacional de Oceanografía, Huatulco, México

Ruiz-Luna *et al.* 1985, Cruz-Romero *et al.* 2000, Rojas-Herrera 2001), which can be due to the sampling methods, selectivity of fishing gears, or a higher fishing pressure that makes organisms mature at a smaller length.

This species is long-lived because the growth parameter or growth rate (K), which determines the swiftness with which the fish reaches its asymptotic length is low (K = 0.24 yr^{-1}) and the maximum age of this species was estimated to be at least 12 years. A high value for this growth rate would indicate a short-lived species that reaches its asymptotic length (L_∞) in one or two years (Salgado-Ugarte *et al.* 2005).

The current landing of *Lutjanus peru* in Bufadero Bay includes 65.84% immature individuals (669 of 1,016 fish sampled). This trend to harvest immature fish is due a commercial preference for "platillero" (plate size) fish. It is also because these small fish obtain the best price in the tourism sector. Small restaurants (palapa), prefers to sell 6 small fish, equivalent to 0.500 kg for $100.00 pesos each than a single 3 kg fish for 280 pesos. The "huachinango" (red snapper) fishery constitutes up to 60% of the fishers' income.

As a measure for protecting this species from overfishing, we suggest a close season during August and September, to give a longer period for spawning, and a first size of capture at 45 cm of length equivalent to 3 years of age, when most females have reproduced.

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