Growth and Emigration of White Shrimp, *Litopenaeus vannamei*, in the Mar Muerto Lagoon, Southern Mexico

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Abstract

Microcohorts of white shrimp, *Litopenaeus vannamei*, were sampled with a cast net at fortnightly intervals in the Mar Muerto Lagoon, Southern Mexico. Shrimp recruited to the lagoon throughout the sampling period (January to August 1993). Mean growth rates of microcohorts ranged from 0.21 to 1.21 mm total length (TL) per day. Juvenile shrimp mainly between the sizes of 70 to 80 mm TL emigrated from the lagoon. Growth and the onset of emigration appeared to be related to water salinity.

Introduction

In 1998, commercial landings of penaeid shrimp in Mexico were about 48 600 t valued at US$270 million (Secretaría del Medio Ambiente, Recursos Naturales y Pesca, 1999). The Pacific shrimp fishery generates 61% of Mexican shrimp and the Gulf of Tehuantepec region contributes 16.7% to this production. In the Gulf of Tehuantepec, Pacific coast of Southern Mexico, *Litopenaeus vannamei* is numerically the most important species in estuarine landings and represents 40% of the oceanic harvest.

The distribution of *L. vannamei* extends from Mexico to Peru. Like many penaeids, it utilises coastal lagoons during the juvenile phase of its life cycle and migrates offshore for subsequent maturation and reproduction (Garcia and Le Reste 1981). The magnitude of the Mar Muerto Lagoon shrimp production and its importance as the largest nursery ground in the Gulf of Tehuantepec suggests the desirability of investigating the growth of *L. vannamei* and factors responsible for the onset of offshore emigration. It is noted that Mar Muerto Lagoon has no resource management plan due mainly to scarce biological information on this shrimp.

The Mar Muerto Lagoon system (Figure 1) is one of the largest estuaries in Mexico and provides nursery habitat for white shrimp and several fish species. *L. vannamei* typically constitutes 95% of catches with daily peaks in production reaching 10 tons. An oceanic fishery also depends on *L. vannamei*, largely in the southern Gulf of Tehuantepec.

Most penaeid shrimp exhibit rapid growth which is correlated with environmental factors. No information is available on the growth of the Mar Muerto Lagoon penaeids. While the timing of shrimp emigration from estuaries varies with species and geographic area, a number of factors have been suggested as causal stimuli

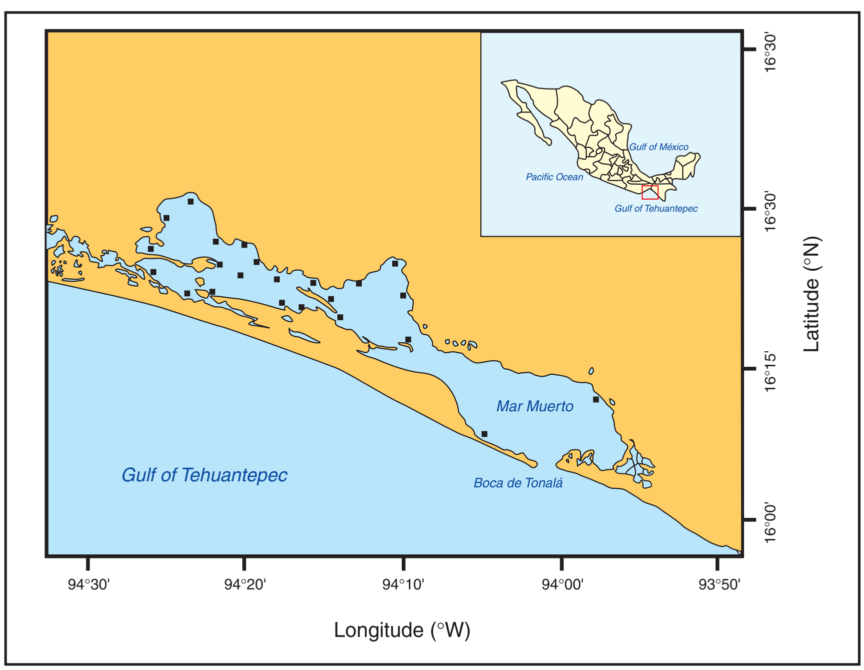

Fig. 1. Map of Mar Muerto Lagoon, México showing the sampling stations.

(see Garcia and Le Reste 1981 and Garcia 1984 for a review).

This paper presents the first estimates of seasonal differences in growth rates and emigration for *L. vannamei* in Southern Mexico.

Materials and Methods

Sampling was carried out in the Mar Muerto Lagoon; 23 sampling stations were selected (Figure 1). Samples were collected between January-August 1993 at 2-week intervals. A cast net with 10 mm nylon mesh and a circular area of 28 m^2 was used. Cast net efficiency and avoidance due to depth was set at 70% and 30% respectively. At each station, five throws were taken around a previously fixed stick. Catches were immediately sorted and counted and then total length (mm) and weight (g) were determined. Water temperature (°C) and salinity (ppt) were recorded at each station.

The castnet length-frequency data was used to construct length-frequency histograms. A computer program, MIX (MacDonald 1986), was used to fit normal curves to the component cohorts in each distribution. Growth rates were estimated by following the mean size of the youngest cohort over consecutive sampling periods. Older cohorts were excluded from the analysis because of the effect of emigration on the cohort mean. Modal progression graphs (Laurec and Le Guen 1981) were constructed from seven microhabitats identified in the lagoon.

A tiny shrimp fishery operates throughout the main channel and employs 200 m long and 1.5 m wide gillnets. Fortnightly catch samples were treated in the same manner as above, as well as recording site and duration of operation. Tiny shrimp fishery samples provided the approximate size of shrimp at the onset of emigration (L_e). Declines in the frequency of shrimp within the emigrating size classes over consecutive sampling intervals were used to identify possible periods of emigration.

The length-weight relationships were estimated using the computer program FISHPARM (Prager et al. 1989) that implements Marquardt's algorithm for nonlinear least-squares parameter estimation.

Results and Discussion

Shrimps were captured throughout the periphery of the lagoon and in limited numbers along the main channel. Catches were highest in the protected areas of the lagoon (locally called "tablón") where depth was less than 1 m and bottom substrate was muddy. Shrimps concentrated in the middle of the lagoon for most of the sampling period and in the connection channel with Oriental Lagoon.

Juvenile shrimp were present throughout the sampling period declining over the month of February and increasing during March to May (Figure 2). This abundance pattern is a product of the dry season postlarval recruitment reported in this area (Medina-Reyna et al. 1998). During June, juvenile shrimp were heavily fished and abundance was at a minimum.

Growth rates were estimated over the size range 40-110 mm TL (Table 1). Microcohorts were identified succesfully in all the different habitats along the lagoon. Growth rate estimates ranged from 0.20 to 1.21 mm TL per day. Microcohorts exhibited a seasonal fluctuation in their growth pattern due to climatic conditions (Table 2). The mean growth rate during the dry season was 0.44 mm TL per day, and 0.61 mm TL per day during the rainy season. This suggests that salinity affects mean growth rate.

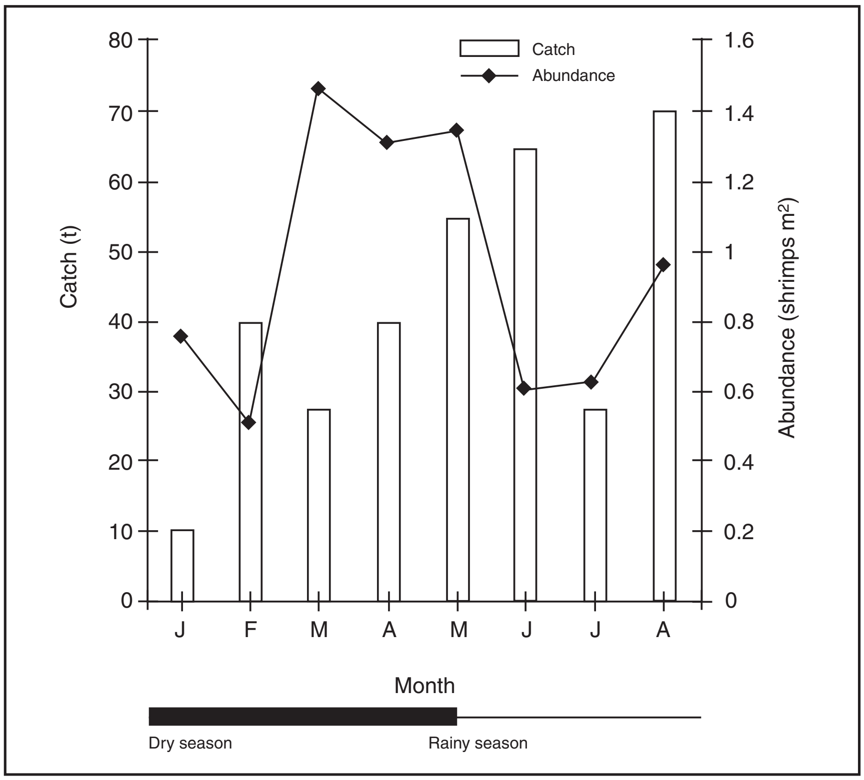

Fig. 2. Abundance pattern of* L. vannamei *in the locality of Santana-Chileta tablon. Bars indicate the monthly catch recorded for the cooperative-holder of the tablon.

Table 1. Growth rate of white shrimp microcohorts estimated by habitat in the Mar Muerto Lagoon, Mexico.

Habitat	Microcohort	k (mm/d)	TL Range(mm)	Season
Reforma Agraria	1	0.45	60-75	Dry
	2	0.61	40-60	Dry
	3	0.31	40-60	Dry
	4	0.48	45-70	Dry
	5	0.51	50-90	Rainy
	6	0.81	65-80	Rainy
Estero Tular	1	0.47	60-75	Dry
	2	0.24	55-65	Dry
	4	1.21	50-110	Rainy
	5	1.01	55-90	Rainy
	6	0.65	49-90	Rainy
La Angostura	1	0.42	40-60	Dry
	2	0.51	65-90	Rainy
	3	0.31	60-65	Rainy
San Andres	1	0.37	70-80	Dry
	2	0.35	60-70	Dry
	3	0.35	50-90	Rainy
	4	0.41	50-70	Rainy
	5	0.38	50-70	Rainy
Los Tules	1	0.55	75-85	Dry
	2	0.61	55-85	Dry
	3	0.20	75-85	Dry
	4	0.66	60-95	Dry
	5	0.56	45-100	Dry
	6	0.40	75-95	Rainy
	7	0.70	50-95	Rainy
	8	0.59	50-70	Rainy
	9	0.77	50-65	Rainy
Santa-Chileta	1	0.44	65-90	Dry
	2	0.67	60-85	Dry
	3	0.63	45-95	Dry
	4	0.73	65-80	Rainy
	5	0.50	60-100	Rainy
	6	0.38	65-95	Rainy
	7	0.59	45-90	Rainy
	8	1.01	55-75	Rainy
Punta Paloma	1	0.41	65-90	Dry
	2	0.40	75-100	Dry
	3	0.47	65-105	Dry
	4	0.64	65-100	Rainy
	5	0.69	50-95	Rainy

Table 2. Seasonal mean growth rates (mm/d) of white shrimp (L. vannamei) *estimated in the Mar Muerto Lagoon, Mexico. Standard deviations in parentheses.*

Habitat	Dry season	Rainy season
Reforma Agraria	0.46 (0.105)	0.66 (0.152)
Estero Tular	0.27 (0.151)	0.97 (0.243)
La Angostura	0.42 (0.054)	0.41 (0.102)
San Andres	0.36 (0.011)	0.37 (0.037)
Santa-Chileta	0.62 (0.107)	0.62 (0.236)
Los Tules	0.52 (0.163)	0.61 (0.137)
Punta Paloma	0.43 (0.030)	0.66 (0.027)
Mean growth rate	0.44 (0.103)	0.61 (0.181)

The highest mean growth increments calculated for the habitats showed some areas were more favorable for juvenile shrimp. These estimates are at the lower end of those made for other lagoons from the Pacific side of Mexico (Table 3). Intraspecific space allocation for juvenile shrimps impacts food partitioning and growth could be limited due to overcrowding (Universidad de Sinaloa 1987).

Length-weight relationships estimated in two localities in the lagoon during the two seasons (Table 4) showed that juvenile shrimp may be under adverse conditions (b=2.5-2.6) during the dry season, while conditions were more favorable (b=2.9) during the rainy season.

Microcohorts entered the lagoon system throughout the sampling period. Cohorts emigrated at about 2.5-4.0 months (72 to 121 days) after estuarine recruitment (Table 5). *L. vannamei* began to leave the lagoon upon attaining about 60 mm TL with most emigration occurring between 70 and 80 mm TL. Size at emigration increased with progression of the rainy season (Table 5). Mortality during the dry season appears to limit the abundance of microcohorts grown under stressful conditions and high fishing effort prevailing during this period (Medina-Reyna1999), and affects subsequent oceanic recruitment. The rainy seasons's microcohorts spent relatively more time in the lagoon growing at higher rates compared to dry season microcohorts.Emigration did not appear to be related to temperature as thermal oscillation is not strong in this region of Mexico. Emigration was related to salinity fluctuations. In fact, the relationship was inverse (Le= 90.355-1.4184 (Salinity, r= -0.784, p<0.05) due to the antiestuarine condition prevailing during dry season (Figure 3). Emigration occurs all-year round in Mar Muerto Lagoon and appears to be influenced by salinity conditions. It is noted that increased

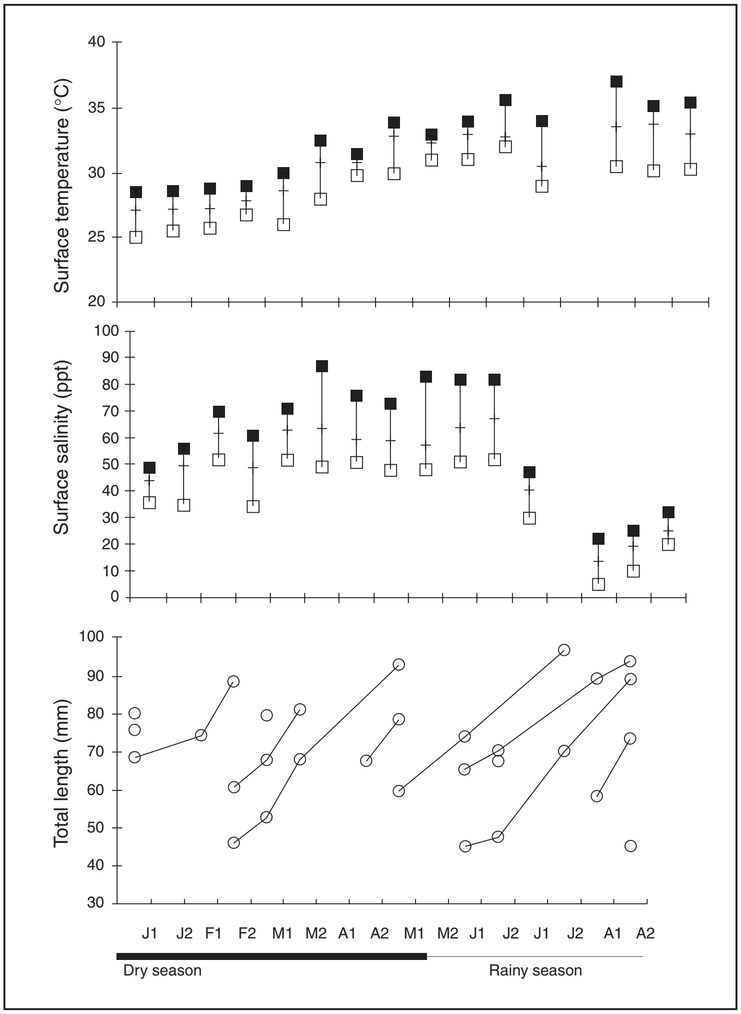

Fig. 3. Mean total length of* L. vannamei *in the Mar Muerto Lagoon over time; vertical bars indicate mean* (+)*, maxima* (■)*and minima* (□)*.

Table 3. Comparison of mean growth rates (mm/d) of white shrimp* (L. vannamei) *in habitats sampled in Mar Muerto Lagoon and other coastal lagoons in Mexico.

Habitat/Area	Highest	Lowest
Reforma Agraria	0.81	0.31
Estero Tular	1.21	0.24
La Angostura	0.51	0.31
San Andres	0.41	0.35
Santana-Chileta	0.77	0.20
Los Tules	1.01	0.38
Punta Paloma	0.69	0.40
Huizache (1969)*	2.85	0.88
Huizache (1973)*	1.96	0.88
Huizache (1973-74)*	1.64	0.51
Huizache (1974)*	1.54	0.53
Huizache (Edwards 1977)	1.78	1.29
Palmillas *	1.23	0.24
Mar Muerto Lagoon (This study)	1.21	0.20

* cited in Universidad de Sinaloa, 1987

productivity of coastal waters (associated with increased rainfall and reduced salinities) may be the direct causative factor affecting growth (see Garcia and Le Reste 1981, Garcia 1984).

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Table 4. Length-weight relationship of white shrimp* (L. vannamei) *sampled in the Mar Muerto Lagoon, Mexico.

Locality	Season	a	b	r^2	n
Rancho Salinas	Dry	0.016	2.6	0.85	163
Rincón Juárez	Dry	0.018	2.5	0.86	207
Rancho Salinas	Rainy	0.011	2.9	0.97	76
Rincón Juárez	Rainy	0.010	2.9	0.98	186

Table 5. Monthly variation of length (L_e), weight (W_e) and age (A_e in days) at emigration of white shrimp* (L. vannamei) *estimated in the Mar Muerto Lagoon. Weights were calculated using parameters in Table 4.

Month	Season	L_e (mm)	W_e (g)	A_e (days)
January	Dry	75.7	3.6	100
February	Dry	76.1	3.7	101
March	Dry	59.4	1.8	72
April	Dry	60.2	1.8	73
May	Dry	-*	-*	*-
June	Rainy	66.3	2.5	84
July	Rainy	79.5	4.2	106
August	Rainy	88.1	5.6	121
Mean		72.2	4.4	94

* no sampling due to adverse weather condition

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