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Metal Content of the Gulf of California Blue Shrimp *Litopenaeus stylirostris* (Stimpson)

M. G. Frías-Espericueta · G. Izaguirre-Fierro · F. Valenzuela-Quiñonez · J. I. Osuna-López · D. Voltolina · G. López-López · M. D. Muy-Rangel · W. Rubio-Castro

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Abstract The blue shrimp *Litopenaeus stylirostris* is the main target species of the Gulf of California shrimping fleet, and its heavy metal content might be of concern for human health because of the increasing contamination of the Gulf. The Cd content of shrimp caught by commercial trawlers ranged from 0.38 to 1.05 μg/g and the mean value was significantly lower in the northern fishing grounds. Pb ranged from 3.19 to 9.59 μg/g and was significantly higher in the northern area. There were no significant geographic difference in the case of Cu and Zn (respective means = 25.4 and 57.8 μg/g).The mean values of all metals show that none is of particular concern for human health.

Keywords Shrimp · Metals · Gulf of California

The Gulf of California (NW Mexico) is a semi-enclosed water body that supports an important shrimp fishery and is surrounded by the desert coasts of northern and southern Baja California to the west, whereas to the east lie the coasts of Sonora and Sinaloa. These are among the leading Mexican states for intensive agriculture and for shrimp culture, with close to 386,280 ha of agricultural land and 56,424 ha of shrimp ponds (SAGARPA 2007). The effluents of these activities, as well as the industrial and urban wastewaters, are discharged with little or no treatment to the Gulf of California or to its coastal lagoons.

This is of concern, because heavy metals are accumulated in sediments and aquatic organisms, and may by transferred to man through the food chain. For this, the assessment of metal levels in aquatic organisms has become important for environmental and human health (Pourang and Dennis 2005) and this is especially the case in Mexico where, in spite of the public policies directed to safeguard the environment and human health, there is evidence of metal contamination of the marine coastal zone (Páez-Osuna and Ruiz-Fernández 1995a, b).

The aim of this work was to assess the Cd, Cu, Pb and Zn content of the edible part (muscle) of the marine shrimp *Lytopenaeus stylirostris*, which is the most important species in the landings of the Gulf of California shrimping fleet.

Materials and Methods

Starting in September 2004 and through February 2005, samples of *L. stylirostris* were obtained by federal observers stationed on board commercial shrimp trawlers, from a total of 19 stations in four fishing areas of the Gulf of California (Fig. 1). Shrimp of nearly equal total length (17.6 ± 1.7 cm) in order to minimize the effect of body size (NAS 1980), were stored at –20°C in metal-free plastic bags kept in an insulated ice box until arrival to the laboratory, where the samples were thawed and dissected to separate the edible muscle.

M. G. Frías-Espericueta · G. Izaguirre-Fierro · F. Valenzuela-Quiñonez · J. I. Osuna-López · G. López-López
Environmental Studies Laboratory, Faculty of Marine Sciences, Autonomous University of Sinaloa, P.O. Box 1132, Mazatlán 82000, Sinaloa, Mexico

D. Voltolina (✉)
UAS-CIBNOR Laboratory, Center of Biological Research of the North West, P.O. Box 1132, Mazatlán, Sinaloa, Mexico
e-mail: voltolina@mzt.megared.net.mx

M. D. Muy-Rangel · W. Rubio-Castro
CIAD, Culiacán Unit, Culiacán, Sinaloa, Mexico

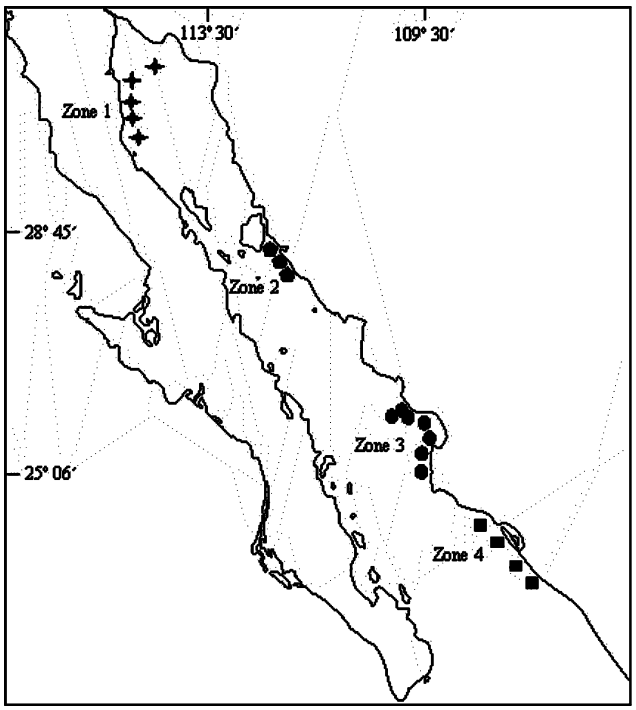

Fig. 1 Location of sampling stations

After acid digestion of the muscle, the concentrations of the four metals were determined by atomic absorption spectrophotometry with the method of internal standard additions as described by Frías-Espericueta et al. (2005). All material used in sampling and analysis was acid-cleaned (Moody and Lindstrom 1977). The reference material was shrimp tissue homogenate MA-A-3/TM and the percentages of recovery of Cd, Cu, Pb and Zn concentrations were within the accepted values (IAEA 1987). Statistical differences among zones were assessed by one-way analysis of variance ($\alpha = 0.05$) (Miller and Miller 1988).

Results and Discussion

The lowest and highest Cd values (1.05 and 0.38 μg/g) were in stations 1 and 16 (Zones IV and I), and concentrations tended to increase at lower latitudes, with significant differences between zone I, in comparison to zones III and IV, that had the higher mean values (Fig. 2), possibly because of natural Cd levels or of the large amounts of fertilizers used in Sinaloa and Sonora for intensive agriculture, that are important sources of metals including Cd (Alloway 1990; Frías-Espericueta et al. 2005). This metal, through the several rivers and the drainage ditches may reach the marine coastal sediments, where it impacts marine benthic organisms, that tend to concentrate metals to a higher degree than nectonic species (Çoğun et al. 2005).

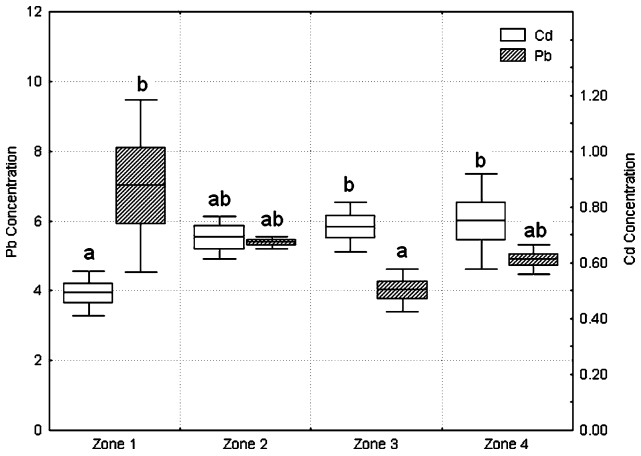

Fig. 2 Mean Cd and Pb values (μg/g, dry weight)

The mean Cd value (0.66 μg/g) is lower than the 6.11 μg/g reported by Vazquez et al. (2001) in *L. setiferus* from the Gulf of Mexico, and similar to the 0.61 and 0.77 μg/g found in *L. stylirostris* and *L. vannamei* caught close to the Marias Islands (Mexican Pacific ocean: Páez-Osuna and Ruiz Fernandez 1995a, b), although it is higher than the value of 0.1 μg/g reported in *P. californiensis* from the west coast of Baja California (Páez-Osuna and Tron-Mayen 1995)

Pb concentrations ranged from 3.19 to 9.59 μg/g and the highest values were in Zone I, that had a mean value significantly different from that of zone III (Fig. 2), possibly because of atmospheric and oceanographic transport and/or from earlier Colorado River discharges, considering that the close to 242,000 square miles of the drainage basin of this river received the runoff from agricultural areas and abandoned mines, and that the national Contaminant Biomonitoring Program documented that the concentrations of some metals (including Pb) of the lower Colorado River were above background levels (McCaulou et al. 1994).

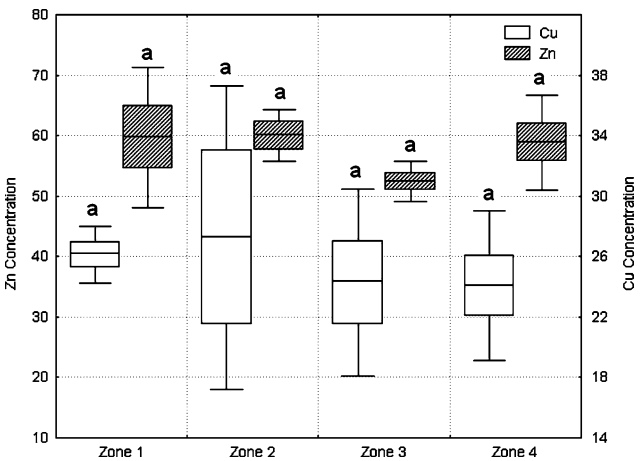

Fig. 3 Mean Cu and Zn values (μg/g, dry weight)

Table 1 Comparative heavy metal concentrations (μg/g, dry weight) in muscle of marine shrimp from other areas of the world

Site	Species	Cd	Cu	Pb	Zn	Reference
Sunderban, India	*P. monodon*	0.74		32.1	1184	Guhathakurta and Kaviraj (2000)
Iskenderun Gulf, Turkey	*P. monoceros*	0.72	23.9	13.8	64.2	Kargin et al. (2001)
Gulf of Mexico	*P. setiferus*	6.11	17.3	7.73	107	Vazquez et al. (2001)
Persian Gulf	*P. merguiensis*	0.31	20.3		47.3	Pourang and Dennis (2005)
Iskenderun Gulf, Turkey	*P. semisulcatus*	3.47	32.2	19.1	53.7	Çoğun et al. (2005)
Gulf of California	*L. stylirostris*	0.66	25.4	5.3	57.8	This study

Table 2 Ingestion (g wet weight/person/day) of shrimp muscle to reach levels of concern (FDA 1993 and WHO 1998)

Metal	Zone I	Zone II	Zone III	Zone IV	Levels of concern μg/person/day
Cd	562	398	378	367	55
Cu	574	550	617	623	$>3 \times 10^3$
Pb	535	698	934	766	750
Zn	2,765	3,747	4,292	3,822	$>45 \times 10^3$

As in the case of Cd, the mean Pb value found in this study (5.32 μg/g) is lower than the 7.73 μg/g reported for *L. setiferus* from the Gulf of Mexico, which is a zone with intense anthropogenic activities.

There was no clear tendency in the geographic variability of Cu and Zn (Fig. 3). The respective highest values (38.32 and 80.37 μg/g) were determined in zones II (Cu) and I (Zn), the lowest for both metals were in zone III, and there were no significant geographic differences ($\alpha = 0.05$), probably because shrimp can regulate their internal Cu and Zn concentrations and this ability ceases only at high external levels of Cu and Zn (Rainbow 1996), which is not the situation of the Gulf of California.

Páez-Osuna and Ruiz-Fernández (1995a, b) reported 36.6, 74.6 μg/g of Cu and Zn in *L. stylirostris* and 27.5, 70.4 μg/g in the case of *L. vannamei* of the Marias Islands, which are higher than our mean values, although Páez-Osuna and Tron-Mayen (1995) and Vazquez et al. (2001) observed lower Cu levels in *P. californiensis* (18.2 μg/g) and *L. setiferus* (17.3) but higher values of Zn (74.6 and 107 μg/g, respectively).

Pb is generally considered a source of ecological concern, but the mean value found in this study is lower than those found in other marine and coastal areas (Table 1, 2) while that of Cd is comparable to those given by Guhathakurta and Kaviraj (2000) and Kargin et al. (2001) for *P. monodon* and *P. monoceros*, and lower than those determined in *P. setiferus* and *P. semisulcatus* from the Gulf of Mexico and from the Turkish Iskenderun Gulf.

A comparison of the metal concentrations found in this study to the levels of risk reported by FDA and WHO shows that none is of particular concern, because the amount which may be consumed daily by an adult person ranges from >350 to close to 560 g of wet tissue/day.

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