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Metals in Fish and Shrimp of the Campeche Sound, Gulf of Mexico

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Increased population and industralization all over the world have lead to concerns of heavy metal pollution in the aquatic environments. In aquatic ecosystems, heavy metals receive attention due to their toxicity and accumulation in biota (Mance 1987). Some metals are biologically important and are toxic to living organisms only at high concentrations, whereas other metals are toxic even at low concentrations. Toxicity of metals influences the physiological functions of organisms such as fish (Farag et al. 1995). The study of heavy metal accumulation in tissues of fish is therefore important to understand the use of fish as indicators of environmental accumulation (Hanson 1997). Field measurements of metal accumulation by fish may also facilitate detailed assessment of ecological risk.

In this paper, we present concentrations of Cu, Pb, Cd, Cr, Mn, Zn, Ag, Ba, and Fe in fish (*Syacium gunteri* and *Lutjanus analis*) collected from the Campeche sound, Gulf of Mexico (Fig. 1). We also present the concentrations of metals in a commercially important shrimp (*Penaeus setiferus*) in the study area. The results are discussed within the context of metal concentrations in fish and shrimp adjacent to oil and gas platforms (Fig. 1). Concentrations of metals in fish samples were also compared with metals in red snapper (*Lutjanus campechanus*) and grey triggerfish (*Balistes capriscus*) of the Gulf of Mexico.

MATERIALS AND METHODS

Fish and shrimp samples were collected using a trawl net during March 1997 from three areas A, B, and C in the Campeche sound, Gulf of Mexico (Fig. 1). Campeche sound is in a southern zone of the Gulf of Mexico and is of great concern because of recreation and petroleum activities. Areas A and B are approximately 14 and 15 km, respectively, from the oil and gas platform while area C is adjacent to the platform (Fig. 1). Areas A, B, and C are 30, 50, and 55 m deep, respectively. The sediments of the area have high contents of CaCO3. Surface water current speed, temperatures, salinities, and dissolved oxygen during collection ranged from 0.9 - 1.8 km h^{-1}, 23.1-25.4 °C, 34.2-36.1, and 197-202 μmol kg^{-1}, respectively.

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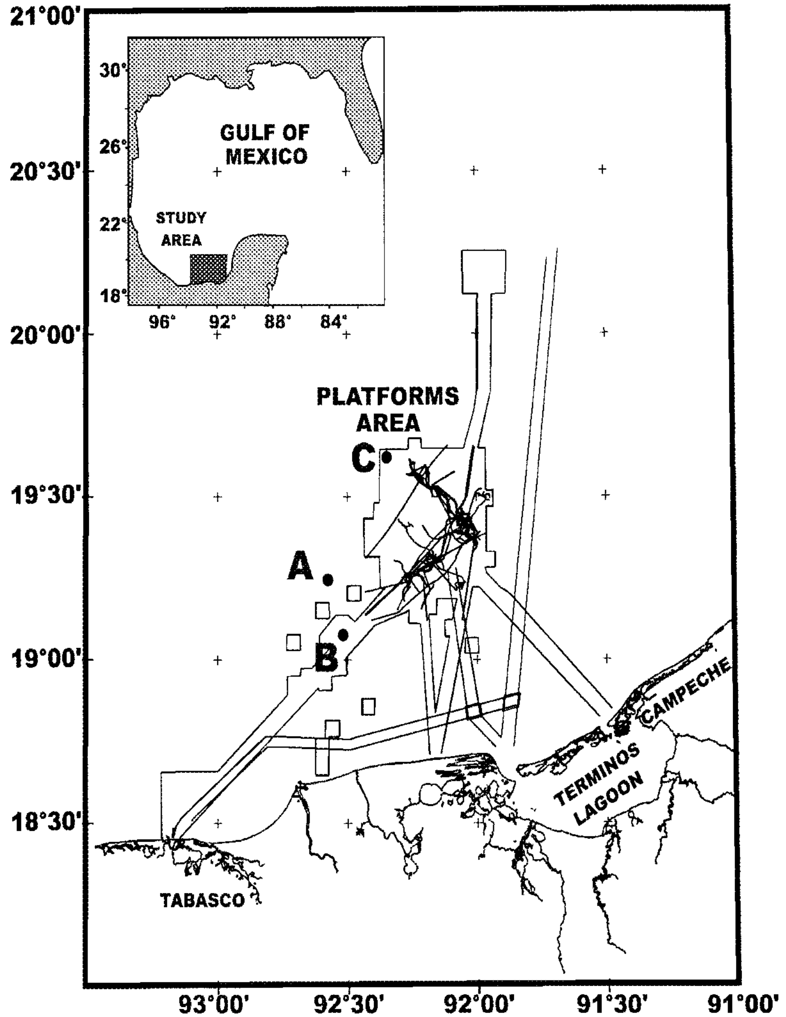

Figure 1. Collection area for samples from the Campeche sound, Gulf of Mexico

After collection, species of fish and shrimp were identified. Ten to twelve of each species were collected. The size of fish and shrimp varied from 10-18 cm and 5-10 cm, respectively. Species were immediately ice-frozen and brought to the laboratory for performing the analysis. In the laboratory, fish and shrimp were dissected to get samples of different species. In fish samples, muscles of ventral area were dissected for analysis. In shrimp samples, an analysis of all muscle portion of shrimp was dissected. The fish samples at some stations were not enough to perform analysis in different sample species.

The different sample species were dried to constant weights at 85 °C. The composite samples of fish and shrimp were obtained by homogenizing each sample species. Homogenization and pulverization were achieved in a teflon mortar. A 0.5 g powder of each sample of the species was put into a digestion vessel and 5 mL of HNO_3, 1 mL of HCl, and 10 mL of deionized water were added to the vessel to carry out digestion. The digestion of metal in samples was done in the microwave (MDS-2000 CEM) for 90 minutes. The conditions were programmed in five stages. In each stage the power, time, tap, and fan were the same and were 100%, 18 minutes, 5 minutes, and 100%, respectively. The pressure in stages were in the order 20, 40, 80, 120, and 175 psi. After digestion, samples were diluted to 25 mL with Milli Q water before determining metal concentration in samples using atomic absorption technique.

Metal concentrations were determined on a Perkin Elmer model 2380 with a graphite furnace Model MGA400. Standard solutions were prepared by dissolving metals in 1:1 solutions of nitric and hydrochloric acids. Certified tuna fish and shrimp homogenates were obtained from the International Laboratory of Marine Radioactivity Mosee Oceanography, Inc. MC 98000, Monaco and were analyzed for metal contents using the same digestion procedure. All values obtained were within 10% of the particular certified sample. Three replicate samples were analyzed to determine our analytical and sample precision. Results for precision varied as a function of metal concentration and typically ranged from 5-9 %. Detection limits (μg/L) in our instrument were: Cu(0.25), Pb(0.15), Cd(0.02), Cr(0.10), Mn(0.20), Zn(0.30), Ag(0.05), Ba(0.90), Fe(1.0), V(0.30), and Co(0.40).

SPSS 6.1 statistical software was used for statistical analysis (Rhudy et al. 1999). Student "t" test was employed to check significant differences between sampling areas and species in the study.

RESULTS AND DISCUSSION

The concentrations of metals in muscle, gonada, and vicera from the two different fish species, *Syacium gunteri* and *Lutjanus analis* at three different areas are presented in Table 1. Metals concentrations, except Ba and Zn, in the muscle of both fish species did not show significant variation as a function of area. The concentrations of Ba and Zn were higher in muscle and gonada tissues of fish from area C than area A (Table 1). Earleir studies have shown higher values of these metals in sediments of the area C and may cause higher values of Ba and Zn in tissues of fish (Macias-Zamora et al. 1999).

Generally, most of the metal concentrations were lower in muscle than gonada and vicera tissues of fish. These results are similar to the studies of other investigators (Bradley and Morris 1986; Gumgum et al. 1994; Pourang 1995; Amundsen et al. 1997). The concentrations of Cu, Pb, Cd, and Mn were higher in gonada than muscle and vicera tissues. The tissues of gonada have faster uptake of metals than muscle tissues and therefore accumulate higher amounts of metals in their tissues (Amundsen et al. 1997).

Table 1. Concentration of metals (μg g^{-1}, dry wt.) in fish and shrimp of the Campeche sound, Gulf of Mexico.

Species	Cu	Pb	Cd	Cr	Mn	Zn	Ag	Ba	Fe
<u>*Fish*</u>									
Syacium gunteri									
				muscle					
A	1.30	1.49	<0.001	8.39	0.10	150	<0.002	9.30	19.1
B	1.30	2.49	<0.001	9.04	0.25	135	<0.002	18.6	34.0
C	1.30	0.99	<0.001	9.64	0.10	202	<0.002	27.7	8.45
				gonada					
A	2.61	8.46	4.88	1.35	0.55	57.4	1.25	18.6	117
C	10.5	2.00	2.45	6.77	0.30	75.7	0.63	32.7	236
				vicera					
B	3.89	<0.15	<0.001	9.81	0.10	51.3	<0.002	18.5	61.3
Lutjanus analis									
				muscle					
B	<0.25	7.37	<0.001	6.18	0.39	41.0	1.54	13.8	54.6
C	<0.25	1.99	<0.001	1.36	0.05	198	0.62	55.7	19.1
<u>Shrimp</u>									
Penaeus setiferus									
				muscle					
A	17.3	7.73	6.11	7.09	0.74	107	0.16	6.99	121
B	17.1	3.21	3.62	1.20	0.25	156	0.77	20.7	126
C	18.6	1.73	1.21	9.99	0.10	55.0	0.46	11.6	59.3
				head					
A	76.2	11.2	13.4	9.54	0.85	74.0	1.40	90.6	265
B	47.3	13.1	15.8	7.39	0.79	61.6	2.02	76.5	214
C	125	10.7	15.9	1.81	1.05	161	2.66	39.6	285

The concentrations of metals in shrimp, *Penaeus setiferus* were highly variable for almost all these metals (Table 1). This suggests that anthropogenic activities in the area may not be causing levels of metals in shrimp. However, most of the metals were higher concentrations in head than muscle of the *P. setiferus* (Table 1). The concentrations of Cu, Mn, Cd, Ni, Fe, and Zn were also lowest in muscle of *Panaeus californiensis* from the northwest coast of Mexico (Paez-Osuna and Tron-Mayen 1995a).

In comparison of metals in shrimp with other studies, the concentrations of Cu found in muscle tissues of *Penaeus setiferus* (17.1 - 18.6 $\mu g\ g^{-1}$) were comparable to the Pacific coast Mexico shrimp *Penaeus stylirostris*, Australian shrimp *Penaeus merguiensis* and *Penaeus monodon*, and the brown and rock shrimp from the U.S. (Texas) continental shelf (Horowitz and Presley 1977; Darmono and Denton 1990; Paez-Osuna and Ruiz-Fernandez 1995b). Cadmium and Cr concentrations (1.21 - 6.11 $\mu g\ g^{-1}$ and 1.20 - 9.99 $\mu g\ g^{-1}$) in *P. setiferus* were found higher than levels of these metals in estuarine and marine populations of *P. stylirostris* (Paez-Osuna and Ruiz-Fernandez 1995b).

The concentration of Zn in muscle tissues of *Penaeus setiferus* (55.0 - 156 $\mu g\ g^{-1}$) were similar to *Panaeus stylirostris* but were higher than in most other Pacific shrimp studied previously, such as *Penaeus merguiensis*, *Penaeus monodon*, *Pandalopsos dispar*, *Panadalus borealis*, *Pandalus platyceros* (Harding and Goyetts 1989; Darmono and Denton 1990; Paez-Osuna and Ruiz-Fernandez 1995b). Manganese concentrations (0.10 - 0.74 $\mu g\ g^{-1}$) in *P. setiferus* were comparable to metal levels in shrimp from the Mexican and Australian Pacific coasts (Darmono and Denton 1990; Paez-Osuna and Ruiz-Fernandez 1995b). The levels of Fe in muscle tissues of *P. setiferus* (59.3 - 126 $\mu g\ g^{-1}$) were similar to Fe concentrations in the estuarine population of *P. stylirostris* (94.7 - 177 $\mu g\ g^{-1}$) but higher than the concentrations of Fe in the marine population of *P. stylirostris* (20.8 - 71.6 $\mu g\ g^{-1}$) (Paez-Osuna and Ruiz-Fernandez 1995b).

The mean concentrations of metals in *Syacium gunteri* and *Lutjanus analis* were compared with fish, *Lutjanus Camechanus* and *Balistes capriscus* from the Gulf of Mexico in Table 2. The metal values in different fish species of the Gulf of Mexico are from relatively uncontaminated areas (Trefry et al. 1996). The variation in the concentration of metals was noticed among different species of fish. A similar observation was found in another study (Amundsen et al. 1997). The concentrations of Pb, Zn, Ba, and Fe in *Lutjanus analis* of our study were higher than these metal values in *Lutjanus Camechanus*. Each species has different process of acquiring metals from the environment and may result in difference in metal values in fish of two studies.

Table 2. Mean concentrations of metals (µg g^{-1}, dry wt.) in different species of fish of the Gulf of Mexico.

Species	Cu	Pb	Cd	Cr	Mn	Zn	Ag	Ba	Fe
Syacium gunteri	3.48	2.57	1.22	95.2	0.23	112	0.31	20.9	79.3
Lutjanus analis	1.29	4.68	<0.01	98.9	0.22	119	1.08	34.7	36.8
*Lutjanus** *Camechanus*	0.80	0.10	<0.01	-	-	13.3	-	0.06	9.0
*Balistes** *capriscus*	1.20	0.13	<0.01	-	-	24.0	-	0.07	8.0

* Concentrations from non discharging platforms in the Gulf of Mexico (Trefry et al. 1996)

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