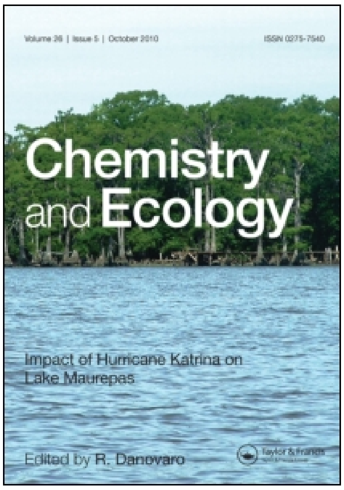

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A Comparative Study On the Levels of Trace Metals in Some Mediterranean and Red Sea Fishes

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A COMPARATIVE STUDY ON THE LEVELS OF TRACE METALS IN SOME MEDITERRANEAN AND RED SEA FISHES

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Samples of *Mugil cephalus, Liza ramada, Siganus luridus, Siganus rivulatus, Epinephelus alexandrinus, Epinephelus areolatus, Epinephelus fasciatus, Epinephelus chlorostigma, Cephalopholis argus* and *Cephalopholis sonnerati* were collected from the Mediterranean and Red Seas and their muscle and bone analyzed by AAS for some trace metals (Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd, Pb). The results showed that these metals accumulate in the bones to a greater extent than in the muscle. The highest accumulated element is cobalt (4.7–20.8 times), while the lowest is lead (1.1–2.5 times). The accumulation is more pronounced in Red Sea species than in Mediterranean species. The elevated levels of lead in *Mugil cephalus* (2.6–3.0 mg kg^{-1}) and *Epinephelus alexandrinus* (3.0–3.9 mg kg^{-1}) were attributed to the intake in food in the polluted environment of Alexandria coastal water. The relationship between body size and concentration of trace metals using a standard linear regression technique gives a significant positive correlation for cobalt, manganese, iron and lead in the muscle, as well as for lead in the bones of *Mugil* species from the Red Sea, while the Mediterranean species showed little correlation.

There is a tendency for increased concentrations of the essential metals manganese, iron and copper with increasing trophic level of the fish, while the opposite is true for the toxic metals chromium and lead. Our results indicate that there is no risk from toxic metal concentrations in muscle of fish from the Mediterranean and Red Seas consumed by man even in contaminated areas.

KEY WORDS Trace metals, fish, Mediterranean Sea, Red Sea

INTRODUCTION

The knowledge of levels of pollutants in edible marine organisms is important from a public health protection viewpoint. In addition, the distribution of trace elements, particularly within the tissues of marine animals, is of interest in understanding the role they play in the biochemical and physiological mechanisms of the organisms. Aquatic organisms require certain trace metals to maintain normal metabolism. When present in excess, however, these essential metals (Fe, Cu, Mn, Co) may exert toxic effects. As to the metals known to be harmful (Cd, Cr, Pb), their toxicity rises with their concentration in an accessible form. Several investigations concerning heavy metals in fishes from the Mediterranean Sea have been carried out, but few studies have been conducted in the Red Sea; no comparative studies have been made previously in these areas.

MATERIALS AND METHODS

Fishing was carried out in five representative areas: Alexandria, Damietta, Port Said, Suez and Ghurgada, as shown in Figure 1. The samples were kept frozen

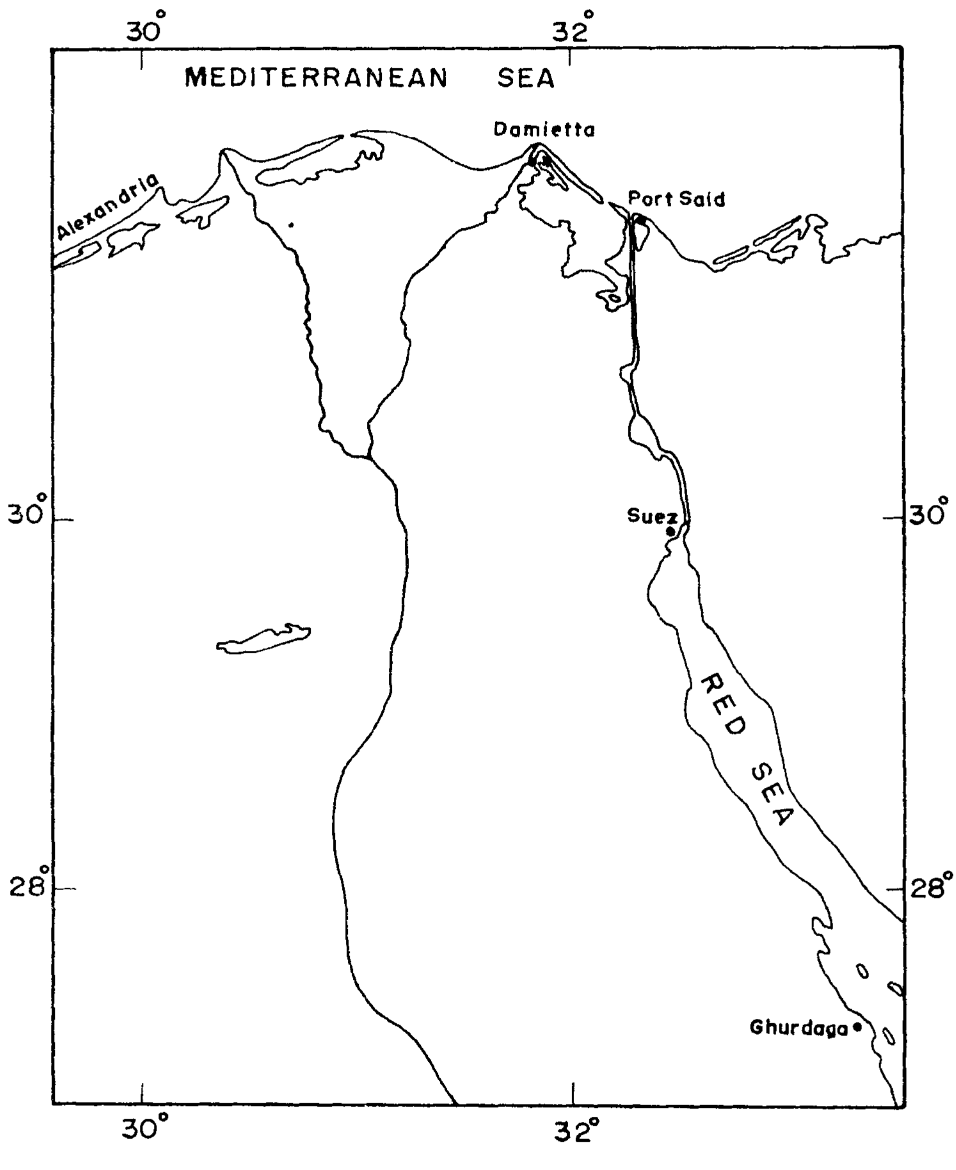

Figure 1 Map to show location of sampling sites.

(–20°C) prior to analysis, identified and prepared for analysis according to Bernhard (1976). Following thawing and homogenization, muscle samples were digested in concentrated nitric acid, while the bones of the fish samples were digested in concentrated nitric and perchloric acids inside Teflon digestion vessels. The resulting solutions, after dilution, were analyzed with a Perkin-Elmer model 373 AAS employing flame techniques. Cr, Mn, Fe, Co, Cu and Pb were determined in all fish samples collected from Mediterranean and Red Seas, while Zn, Ni and Cd were analyzed only in *Epinephelus* species from the Red Sea.

RESULTS AND DISCUSSION

Average concentrations of Cr, Mn, Fe, Co, Ni, Cu, Zn, Cd and Pb in the muscle and bone of *Mugil cephalus, Liza ramada, Siganus luridus, Siganus rivulatus, Epinephelus alexandrinus, Epinephelus areolatus, Epinephelus fasciatus* collected from the Mediterranean and Red Seas are summarized in Table 1. A perusal of this table shows that the muscle and bone of *Mugil* spp. (*Mugil cephalus* and *Liza ramada*) collected from the Red Sea have higher levels of chromium (1.8, 1.5 times), cobalt (1.1, 1.9 times) and copper (2.2, 3.0 times) than the Mediterranean species, while lead shows the reverse.

Siganus sp. from the Mediterranean has higher levels of iron (2.9 times) and manganese (2.8 times) in the muscle compared with the Red Sea species. In addition chromium and cobalt have somewhat higher values in muscle and bone of the Red Sea species in comparison with the Mediterranean species.

The *Epinephelus* spp. from the Mediterranean have higher levels in muscle and bone for chromium, manganese, iron and lead than the Red Sea species.

On the basis of the few *Cephalopholis sonnerati* samples analyzed, manganese and cobalt in muscle, as well as manganese in the bone, have slightly higher concentrations than *Cephalopholis argus,* while other trace metals are at similar levels in both species.

Generally, the existing data on trace metals distribution in various fish species from the Mediterranean and the Red Sea reveal that these metals are present in the bone to a greater extent than in the muscle (Table 2). The ratio of trace metal concentrations (bone/muscle) is highest for cobalt (4.7–18.0) times), while it is lowest for lead (1.1–2.5 times). The relative accumulation is more pronounced for the metals manganese, iron, cobalt and lead in the Red Sea species than in the Mediterranean species.

Our results indicate that the higher levels of lead in specimens of *Mugil cephalus* (1.9–3.0 mg kg^{-1}) and *Epinephelus alexandrinus* (2.96–3.77 mg kg^{-1}) which live in a polluted environment, such as Alexandria coastal water (Shriadah and Emara, 1991), result primarily from uptake of lead from contaminated food and sand particles. This regional pattern is also evident from the higher lead values (1.69–2.23 mg kg^{-1}) in *Epinephelus areolatus* collected from Suez Bay compared with lower values (0.50–0.97 mg kg^{-1}) for specimens from Ghurgada.

Mean muscle concentrations of copper, manganese, and lead in *Mugil* spp. both from the Mediterranean and the Red Sea were generally similar to the limited data for *Mugil* spp. reported by Uysal and Tuncer (1982) in the Bay of Izmir. In contrast, the same authors reported much higher levels for *Mugil auratus* from the Aegean Coast (Table 3). The concentrations of iron reported here for *Mugil* spp. reveal much higher levels than those previously reported in the Mediterranean Sea, while cobalt and chromium are lower. In this study, *Epinephelus* spp. from the Mediterranean showed levels of copper and cobalt comparable to those reported in Kissamos Gulf (Grimanis, *et al,* 1980), chromium is much higher, while cadmium is much lower (Table 3).

Previous studies conducted by El-Deek and Abbas (1990) on *Epinephelus* spp. from the Red Sea showed higher levels of zinc and lead, particularly in the bones, than those reported here (Table 4), but copper values in the muscle were comparable with the present study.

Correlation analysis between body size and concentration of heavy metals using standard linear regression gives a significant positive correlation (at 95% confidence

Table 1 Average concentrations of trace elements (Cr, Mn, Fe, Co, Cu, Pb, Ni, Zn and Cd) mg kg^{-1} wet wt. in muscle (m) and bone (b) of some Mediterranean and Red Sea fishes.

Fish species	*Area*	*Length (cm)*	*Weight (gm)*	*n*	*Cr*		*Mn*		*Fe*		*Co*		*Cu*		*Pb*		*Ni*		*Zn*		*Cd*	
					m	*b*	*m*	*b*	*m*	*b*	*m*	*b*	*m*	*b*	*m*	*b*	*m*	*b*	*m*	*b*	*m*	*b*
M. cephalus	Med.	28.7	230.5	9	0.49	0.95	0.35	0.51	39.0	66.0	0.05	0.42	0.23	0.50	2.67	2.91						
		±2.5	±85.0		±0.2	±0.3	±0.1	±0.2	±7.0	±9.0	±0.03	±0.2	±0.05	±0.2	±0.5	±0.50						
M. cephalus	Red	31.8	224	6	0.49	0.9	0.35	1.3	42.3	89.0	0.08	0.66	0.62	1.57	1.24	2.66						
		±1.8	±62.0		±0.3	±0.2	±0.1	±0.04	±18.0	±5.0	±0.04	±0.3	±0.4	±0.9	±0.5	±0.3						
L. ramada	Med.	21.3	76	1	0.19	0.38	0.31	0.53	41.0	67.2	0.04	0.16	0.29	0.51	1.8	2.23						
		±0.2	±0.7		±0.01	±0.02	±0.01	±0.02	±0.6	±1.0	±0.01	±0.02	±0.05	±0.02	±0.2	±0.40						
L. ramada	Red	28.0	176	4	0.75	1.12	0.15	0.73	18.2	46.2	0.02	0.46	0.68	1.48	0.26	0.68						
		±1.4	±16.0		±0.1	±0.3	±0.06	±0.1	±4.0	±3.0	±0.01	±0.03	±0.3	±0.7	±0.2	±0.20						
S. luridus	Med.	22.9	133.0	4	0.16	0.37	0.82	0.51	78.2	92.0	0.03	0.14	0.29	0.79	0.67	1.0						
		±0.5	±5.0		±0.07	±0.06	±0.07	±0.03	±4.4	±10.0	0.01	0.04	±0.02	±0.03	±0.03	±0.06	±0.04					
S. luridus	Red	20.7	84.0	9	0.34	0.83	0.38	0.78	34.0	76.6	0.06	0.64	0.42	0.76	0.63	1.59						
		±3.0	±36.0		±0.2	±0.1	±0.1	±0.2	±6.0	±12.0	±0.03	±0.02	±0.2	±0.4	±0.2	±0.6						
S. rivulatus	Red	21.6	96.0	4	0.18	0.53	0.19	0.55	21.7	70.7	0.02	0.61	0.25	0.65	0.60	1.30						
		±1.0	32.0		±0.07	±0.2	±0.1	±0.2	±13.0	±12.0	±0.01	±0.01	±0.2	±0.3	±0.1	±0.3						
E. alexandrinus	Med.	40.6	746	6	0.48	0.88	0.78	2.03	74.4	88.8	0.03	0.54	0.48	0.84	2.14	2.4						
		±5.5	±92		±0.1	±0.2	±0.1	±0.5	±13.0	±24.0	±0.01	±0.1	±0.1	±0.1	±0.6	±0.5						
E. areolatus	Red	36.0	574.0	8	0.34	0.85	0.28	0.92	35.8	90.8	0.06	0.67	0.76	1.68	0.89	1.39	0.16	0.44	3.35	4.08	0.19	0.15
		±3.0	±180.0		±0.2	±0.3	±0.10	±0.3	±20.0	±16.0	±0.04	±0.1	±0.4	±1.3	±0.5	±0.7	±0.03	±0.04	±1.4	±0.4	±0.01	±0.01
E. Fasciatus	Red	25.5	233.0	6	0.32	1.26	0.19	0.91	16.2	87.6	0.03	0.65	0.95	2.19	0.31	0.80	0.18	0.46	3.60	3.11	0.13	0.17
		±0.7	±20.0		±0.2	±0.6	±0.01	±0.1	±7.0	±0.6	±0.01	±0.1	±0.3	±1.3	±0.1	±0.1	±0.04	±0.06	±2.5	±0.5	±0.01	±0.01
E. chlorostioma	Red	40.5	853.0	4	0.09	0.25	0.33	0.78	20.2	85.2	0.02	0.68	0.27	0.69	0.39	0.83	0.16	0.76	3.16	3.84	0.21	0.22
		±0.7	±2.0		±0.01	±0.02	±0.02	±0.1	±0.2	±0.6	±0.01	±0.1	±0.1	±0.2	±0.01	±0.2	±0.02	±0.1	±1.0	±0.4	±0.01	±0.01
C. arous	Red	27.5	328.0	2	0.23	0.42	0.17	0.65	39.2	77.0	0.05	0.52	0.73	1.22	0.88	2.23						
		±0.6	±6.0		±0.04	±0.04	±0.02	±0.04	±1.0	±3.0	±0.01	±0.1	±0.1	±0.2	±0.2	±0.4						
C. sonnerati	Red	27.8	320.0	2	0.31	0.38	0.61	1.92	41.6	75	0.07	0.50	0.68	1.39	0.80	1.92						
		±0.6	±7.0		±0.06	±0.04	±0.04	±0.2	±2.0	±0.01	±0.1	±0.02	±0.06	±0.1	±0.2							

M = Mugil; L = Liza; S = Siganus; E = Epinephelus; C = Cephalopholis; m = muscle; b = bone.

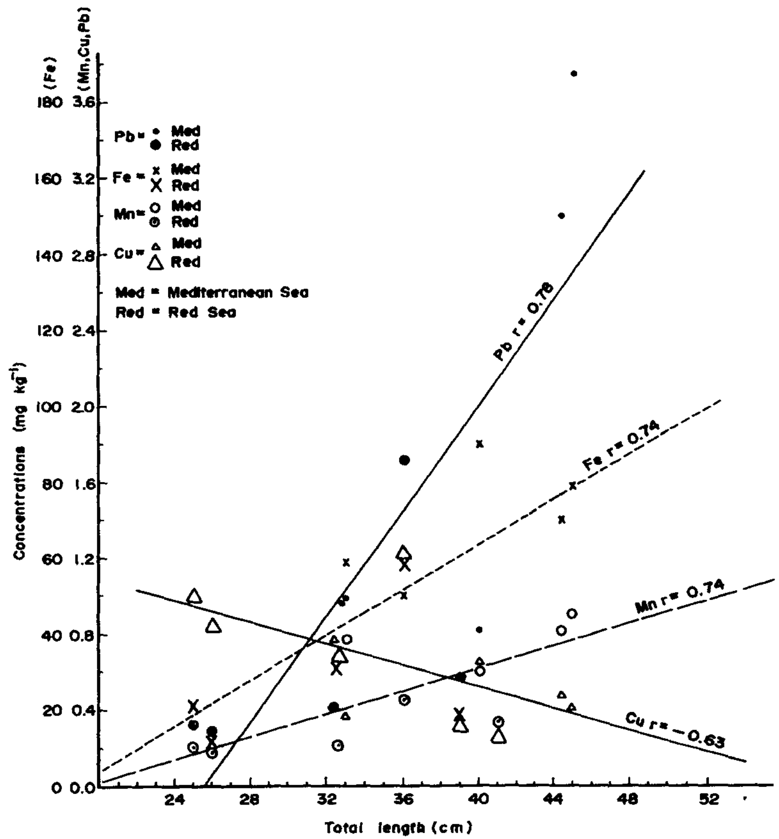

Fig. 3 : Linear regression lines for Mn, Fe, Cu and Pb concentration versus total length relationship in the Muscles of <u>Epinephelus</u> species .

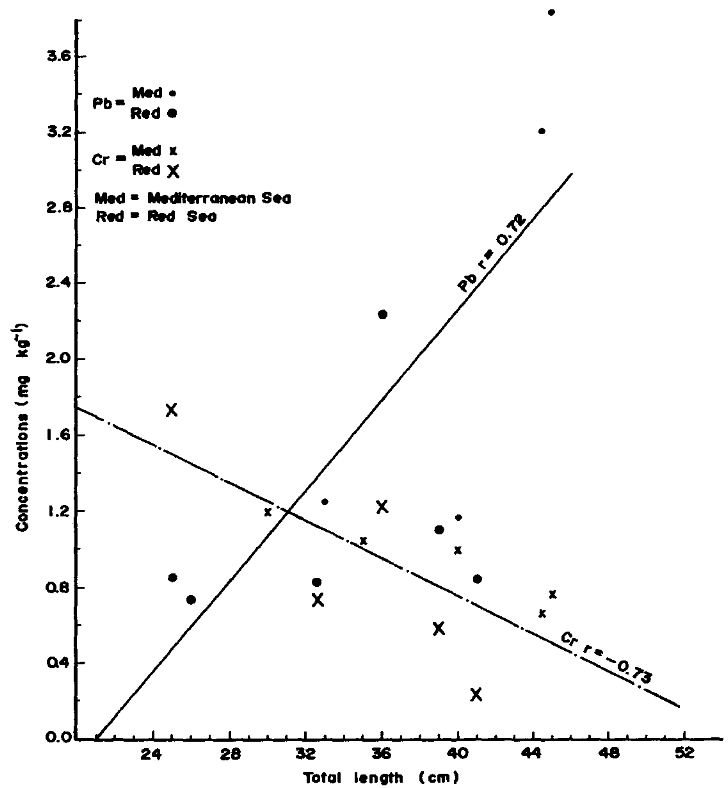

Fig. 4: Linear regression lines for Cr and Pb concentrations versus total length relationship in the bones of <u>Epinephelus</u> species .

In all fish studied, higher concentrations of the essential metals manganese, iron and copper reflect the increasing trophic level of the fish. These three metals are required metabolically by living organisms and the concentrations in the tissues may be actively regulated by these fishes. On the other hand, toxic metals such as chromium and lead have lower values in carnivorous fish (Table 5).

Concentrations of the metals copper, iron, manganese, chromium and lead are significantly correlated with concentrations in the bone. The positive correlations found (Table 6) indicate that they were accumulated in both tissues to the same extent.

The risk to man from consumption of metals in fish/sea food has been discussed by Bernhard (1982). This can be estimated by comparing the metal intake from an observed consumption rate of sea food with a Provisional Tolerable Weekly Intake (PTWI). For the metals cadmium, copper, and lead, PTWI values were calculated to be 300, 245000 and 2800μg per 70 kg man, respectively. The percentage of the present concentrations to that of PTWI was estimated for these metals (Table 7). This table demonstrates that, with the exception of lead in *Mugil* and *Epinephelus* species from the Mediterranean, the concentrations of trace metals in fish reported in this study would be much lower than the PTWI values and accordingly there is no risk from the human consumption of these fish.

Table 5 Average concentrations of trace metals in the muscle (M) and bones (B) of *Mugil* spp, *Siganus* spp., *Epinephelus* spp. and *Cephalopholis* spp.

Fish species		*Cr*	*Mn*	*Fe*	*Co*	*Cu*	*Pb*
Mugil spp.	M	0.51±0.2	0.31±0.1	35.7±11.0	0.046±0.02	0.40±0.2	1.82±1.0
(Omnivorous)	B	0.92±0.3	0.69±0.3	66.6±15.0	0.425±0.26	0.87±0.6	2.40±1.0
Siganus spp.	M	0.24±0.1	0.45±0.3	43.1±26	0.035±0.02	0.33±0.1	0.63±0.20
(Omnivorous)	B	0.61±0.2	0.64±0.2	79.3±13	0.49±0.2	0.74±0.3	1.34±0.5
Epinephelus spp.	M	0.37±0.2	0.47±0.3	45.8±28.0	0.032±0.00	0.63±0.3	1.22±1.2
(Carnivorous)	B	0.89±0.4	1.34±0.7	88.8±16.0	0.62±0.1	1.34±0.9	1.62±1.1
Cephalopholis spp.	M	0.27±0.05	0.39±0.3	40.4±2.0	0.059±0.02	0.71±0.04	0.84±0.06
(Carnivorous)	B	0.40±0.03	1.29±0.9	76.1±1.0	0.51±0.01	1.31±0.1	±2.1±0.2

M = muscle; B = bones.

Table 6 Ratios of the concentration in the bone with that in the muscle tissues, as well as the correlation coefficient (r) of the trace metals in both organs.

Fish	*Area*	*Metals*	*Concen. Ratio (B/M)*	*Correlation Coefficient (r)*	*Level of Signif. (%)*
Mugil sp.	Med.	Pb	1.1	0.92	0.01
		Cr	2.0	0.92	0.01
Mugil sp.	Red	Cu	2.3	0.98	0.02
		Pb	2.2	0.99	0.02
Epinephelus sp.	Med.	Pb	1.1	1.0	0.001
	Red	Cu	2.3	0.88	0.02
		Fe	3.3	0.82	0.05
		Pb	1.8	1.0	0.001
Siganus sp.	Red	Cu	2.0	0.92	0.05
		Mn	2.2	0.91	0.02
		Pb	2.4	0.97	0.01

M = muscle; B = bones.

Table 2 The ratio of trace metal concentrations (bone/muscle) in some Mediterranean and Red Sea species.

Fish	*Area*	*Cr*	*Mn*	*Fe*	*Co*	*Cu*	*Pb*
Mugil spp.	Mediterranean	2.0	1.6	1.7	6.4	1.9	1.2
	Red Sea	1.6	4.0	2.2	11.7	2.4	2.2
Siganus spp.	Mediterranean	2.3	0.6	1.2	4.7	2.7	1.5
	Red Sea	2.6	2.3	2.6	15.6	2.1	2.3
Epinephelus spp.	Mediterranean	1.8	2.6	1.2	18.0	1.8	1.1
	Red Sea	3.2	3.2	3.6	16.8	2.3	1.9
Cephalopholis spp.	Red Sea	1.5	3.3	1.9	8.5	1.8	2.5
Mean	Mediterranean	2.0	1.6	1.4	9.7	2.1	1.3
	Red Sea	2.2	3.2	2.6	13.0	2.2	2.2

Table 3 Comparison between trace metals concentrations (mg kg^{-1}) in the fish muscles in the present study with those reported elsewhere in the Mediterranean Sea. Mean values are given in parenthesis.

Fish	*Cu*	*Mn*	*Fe*	*Pb*	*Co*	*Cr*	*Cd*	*Reference*
Mugil spp.								
Mediterranean	0.16–0.31	0.26–0.42	35–48	1.91–3.0	0.02–0.11	0.19–0.78	-	This study
	(0.23)	(0.35)	(39)	(2.67)	(0.05)	(0.49)	-	
Red	0.27–0.96	0.10–0.19	15–55	0.10–1.60	0.01–0.11	0.31–0.82	-	This study
	(0.64)	(0.25)	(30)	(0.75)	(0.05)	(0.62)		
Mugil spp.								
Bay of Izmir	0.69–1.11	0.27–0.65	3.9–15.7	2.9–3.2	0.35–1.4	0.57–2.72	0.17–0.26	Uysal & Tuncer (1982)
M. auratus								
Aegean coast	5.1–9.0	5.2–8.1	-	12.5–18	-	5.3–8.2	-	Uysal (1980)
Epinephelus	0.38–0.62	0.62–0.81	59–90	0.81–3.77	0.02–0.04	0.39–0.61	-	This study
spp. Med.	(0.48)	(0.79)	(74)	(2.14)	(0.03)	(0.48)		
Red	(0.66)	(0.27)	(24)	(0.53)	(0.04)	(0.25)	(0.17)	
Epinephelus guaza Kissamos Gulf	(0.33)	-	-	-	(0.01)	(0.037)		Grimanis *et al.* (1980)

Med. = Mediterranean Sea; Red = Red Sea

Table 4 Concentrations of Cu, Zn and Pb in Red Sea fishes in this study and those of El-Deek & Abbas (1990) (mg kg^{-1} wet weight).

		Cu		*Zn*		*Pb*	
Fish species		*This study*	*El-Deek & Abbas*	*This study*	*El-Deek & Abbas*	*This study*	*El-Deek & Abbas*
Epinephelus chlorostigma	B	0.69±0.2	1.11±0.7	3.8±0.4	19.5±8.0	0.83±0.2	17.4±11.0
	M	0.27±0.1	0.36±0.3	3.2±1.0	4.7±0.9	0.39±0.1	2.9±1.6
Epinephelus	B	1.68±1.3	8.2±8.0	4.1±0.4	25.5±6.0	1.39±0.7	8.2±3.0
areolatus	M	0.76±0.4	0.73±0.6	3.3±1.4	4.9±1.0	0.89±0.5	7.8±6.0
Epinephelus	B	2.19±1.3	1.36±0.6	3.11±0.5	26.4±8.0	0.80±0.1	17.0±5
	M	0.95±0.3	0.57±0.5	3.6±2.5	4.1±0.9	0.31±0.1	2.8±0.4

B = bones; M = muscle.

limit) for cobalt, manganese, iron and lead in the muscle, as well as lead in the bone of *Mugil* spp. from the Red Sea (Figure 2). On the other hand, the heavy metals in the Mediterranean species were generally poorly correlated with body size of these fish. Strong similarities were found in the muscle content of manganese, iron and lead and body size of *Epinephelus* spp. from both the Mediterranean and the Red Sea (Figure 3), suggesting that fish in the two different seas may be in a steady state with their environment with respect to these metals. Copper shows a reverse relationship with an increase in concentration as the body size decreases; a similar relationship is found for both Mediterranean and Red Sea fish. This inverse relationship with body size is also reported elsewhere (Marks, *et al.*, 1980; Cross, *et al.*, 1973). In the bone of *Epinephelus* spp., little correlation was found between metals and body size except for lead and chromium; the latter was negatively correlated (Figure 4).

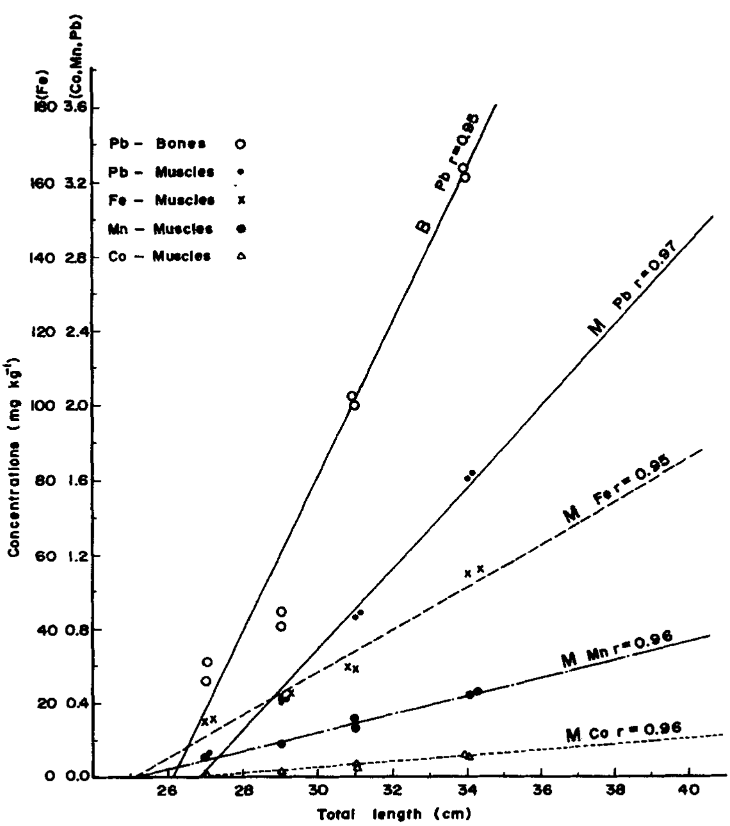

Fig. 2: Linear regression lines for Mn, Fe, Co and Pb concentration versus total length relationship in Mugil species of the Red Sea.

Table 7 Mean concentrations of trace metals Cu, Cd and Pb in fish species from Mediterranean and Red Seas and their percentage of the Provisional Tolerable Weekly Intake (PTWI).

		Mean concentration ($mg\ kg^{-1}$)			*% of the present concentration to that of PTWI*		
Fish species		*Cu*	*Cd*	*Pb*	*Cu*	*Cd*	*Pb*
Mugil spp.	Med.	0.26	–	2.24	0.11	–	80
Mugil spp.	Red	0.65	–	0.75	0.27	–	27
Siganus spp.	Med.	0.29	–	0.67	0.12	–	24
Siganus spp.	Red	0.34	–	0.62	0.14	–	22
Epinephelus spp.	Med	0.48	–	2.14	0.20	0	76
Epinephelus spp.	Red	0.66	0.17	0.53	0.27	5.7	19
Cephalopholis spp.	Red	0.71	–	0.84	0.29	–	30

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