

## **Accumulation of Lead and Zinc Ions in *Limanda limanda* L. Collected from Swansea Bay (South Wales, U.K.)**

**Khalifa S. Al-Khalifa**

*Department of Science, Teachers' College, Al-Rass, Saudi Arabia*

(Received 10/10/1427H.; accepted for publication 20/10/1427H.)

**Abstract.** Levels of lead and zinc in muscle, kidney and liver tissues of *Limanda limanda* L. collected from Swansea Bay (South Wales, U.K.) during July 2006 were estimated by dry weight atomic absorption method. The results showed that *L. limanda* contained zinc in a descending order: kidney < muscles < liver in males and females, while lead was accumulated in the following order: muscles < kidney < liver for all age categories in both genders. Moreover, females accumulated lead and zinc in their muscles, liver and kidney to a level almost two times higher than those accumulated by males of the same age.

**Keywords:** Swansea Bay, Atomic absorption, *Limanda limanda*, Lead and zinc.

### **Introduction**

Heavy metals accumulate in different organs of aquatic animals, therefore levels measured in their tissues can reflect the past exposure. They may exert beneficial or harmful effects on plant, animal and human life regarding their concentration in the environment [1-2]

The degree of bioaccumulation varies from metal to metal and differs from one species to another or organs of the same species [3-4]. Some heavy metals such as zinc, iron and copper are essential to many organisms at certain concentration. Others, however, are either non-essential or toxic, but generally all of them are potentially harmful to most organisms at higher concentrations [5].

At present, different fish tissues are commonly used as indicators of metal concentration of the marine environment [6-7]. The concentration of heavy metals in the tissues of fish are determined primarily by the level of pollution of the water and food and so are indicative of the level of pollution in the environment. The concentrations

themselves are the result of uptake and discharge processes with characteristic kinetics for elements and their biological half life, influenced by the age and size of the individuals [8-10], feeding habits [11-12], species of fish [13-15], and time of collection [9, 15]. The efficiency of metal uptake from polluted water and food may differ in relation to ecological needs, metabolism and metal gradients of water, food, sediment and other factors such as temperature, salinity and interacting agents [16-17]. Moreover, various tissues accumulate heavy metals to different levels, depending on their biochemical characteristics [9, 15].

The present study was undertaken to determine the levels of lead and zinc in the liver, kidney and muscles of *Limanda limanda* L. collected from Swansea Bay in South Wales, U.K.

### Material and Methods

Specimens of *L. limanda*. were collected from Swansea Bay during July 2006 (Fig. 1). Samples of muscle tissue were removed from various areas of the body of the fish together with liver and kidney from at least 21 fish. Three specimens from each tissue or organ were washed with deionized water and transferred to a clean 5 ml conical flasks and oven dried at 95°C for 3-4 days to allow them reach a constant dry weight. After cooling to room temperature, the dry weight of the samples was determined. Tissues or organs were then digested following the procedure of Krishnamurthy *et al.* [18].

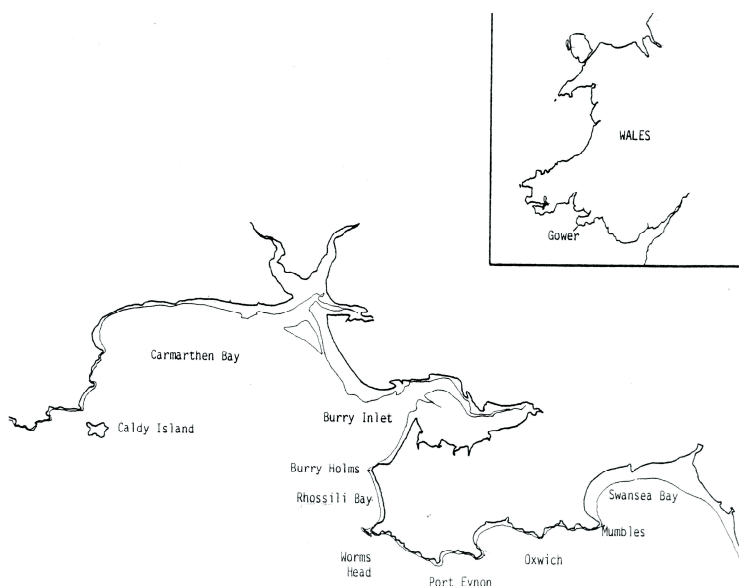


Fig. 1. Location map of sampling site of *L. limanda* L. in Swansea Bay (South Wales, U.K.).

The concentration of the lead and zinc ions in all samples was measured using a Varian Spectra AA plus flame atomic absorption spectrophotometer. Male and female fish were divided into four age categories: 2-3, 3-4, 4-5 and 5-6 age classes. The total length and weight of the fish were recorded. Statistical analysis of the data was carried out by Duncans Multiple Range Test by using SPSS 10.1 Computer Program (SPSS Inc., Chicago, Illinois), and the results were expressed as mean  $\pm$  standard deviation (S.D.).

### Observations

The concentration of zinc and lead ions in the muscles, liver and kidney of males and females of *L. limanda* are given in Table 1 and Table 2. Mainly zinc showed higher levels in muscles, liver and kidney compared to lead in both genders.

**Table 1. Concentrations of zinc ions (ppm/dry weight) in muscles, liver and kidney of *L. limanda***

Class (cm)	Age (Years)	Gender	Muscles	Liver	Kidney
			Mean $\pm$ S.D.	Mean $\pm$ S.D.	Mean $\pm$ S.D.
18-21	2-3	♀	41.76 $\pm$ 5.31	63.40 $\pm$ 11.05	31.21 $\pm$ 7.71
21-24	3-4	♀	37.82 $\pm$ 12.10	62.51 $\pm$ 9.62	29.01 $\pm$ 7.01
24-27	4-5	♀	39.02 $\pm$ 11.62	59.72 $\pm$ 13.20	27.93 $\pm$ 6.82
27-32	5-6	♀	44.43 $\pm$ 13.48	98.61 $\pm$ 23.07	35.52 $\pm$ 8.80
13-17	2-3	♂	26.63 $\pm$ 2.18	23.83 $\pm$ 6.90	22.77 $\pm$ 6.25
17-21	3-4	♂	25.91 $\pm$ 5.12	31.20 $\pm$ 8.10	20.13 $\pm$ 5.02
21-25	4-5	♂	23.14 $\pm$ 3.01	48.73 $\pm$ 11.92	21.19 $\pm$ 4.90
25-28	5-6	♂	27.33 $\pm$ 4.97	52.39 $\pm$ 13.88	24.82 $\pm$ 7.01

**Table 2. Concentrations of lead ions (ppm/dry weight) in muscles, liver and kidney of *L. limanda***

Class (cm)	Age (Years)	Gender	Muscles	Liver	Kidney
			Mean $\pm$ S.D.	Mean $\pm$ S.D.	Mean $\pm$ S.D.
18-21	2-3	♀	12.51 $\pm$ 6.10	14.3 $\pm$ 7.50	12.62 $\pm$ 6.12
21-24	3-4	♀	11.90 $\pm$ 5.98	14.1 $\pm$ 7.12	12.11 $\pm$ 6.01
24-27	4-5	♀	11.70 $\pm$ 5.80	13.8 $\pm$ 6.91	13.02 $\pm$ 7.92
27-32	5-6	♀	13.10 $\pm$ 7.73	17.2 $\pm$ 9.60	15.83 $\pm$ 9.41
13-17	2-3	♂	5.10 $\pm$ 2.20	6.32 $\pm$ 3.11	5.12 $\pm$ 2.03
17-21	3-4	♂	4.71 $\pm$ 2.02	6.17 $\pm$ 2.81	5.99 $\pm$ 2.00
21-25	4-5	♂	3.69 $\pm$ 1.97	5.88 $\pm$ 2.36	6.18 $\pm$ 2.71
25-28	5-6	♂	5.92 $\pm$ 2.81	7.66 $\pm$ 3.65	6.96 $\pm$ 3.33

In the four age categories of females, zinc and lead concentrations, in descending order, were liver, muscles and kidney. No significant difference ( $P > 0.5$ ) in zinc and lead concentration per unit dry weight was noticed between fish with a total length of 24-27 cm and younger fish with a total length of 18-21 cm. There was a significant difference ( $P < 0.1$ ) in the concentration of zinc and lead in muscles, liver and kidney between 27-32 cm fish (5-6 age classes) and 18-21 cm fish (2-3 age class) (Figs. 2-7).

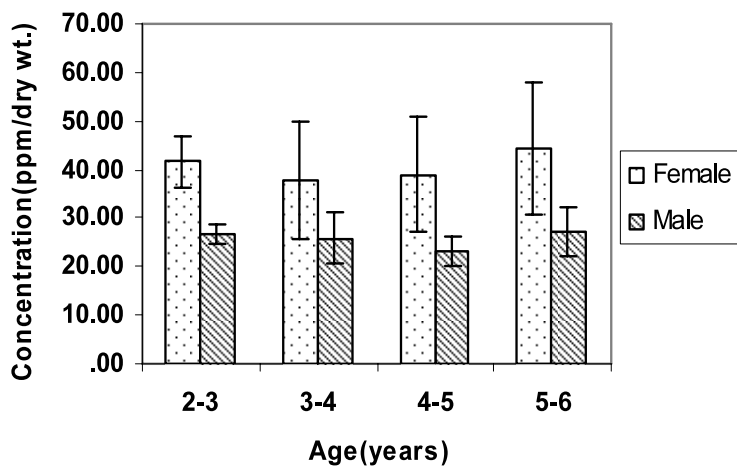


Fig. 2. Concentrations of zinc ions in muscles.

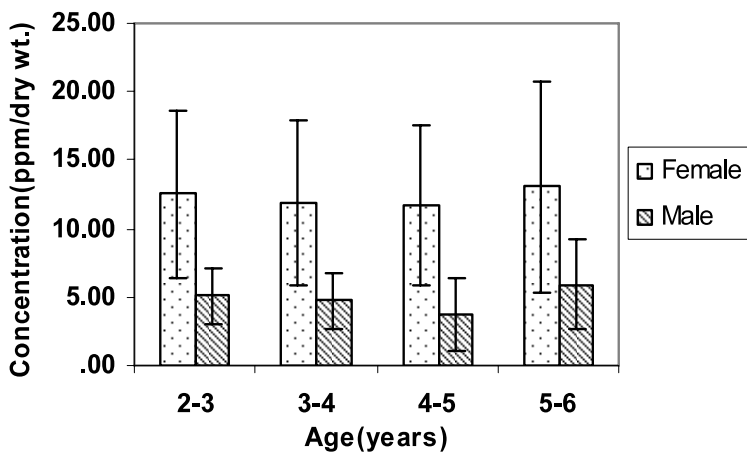


Fig. 3. Concentrations of lead ions in muscles.

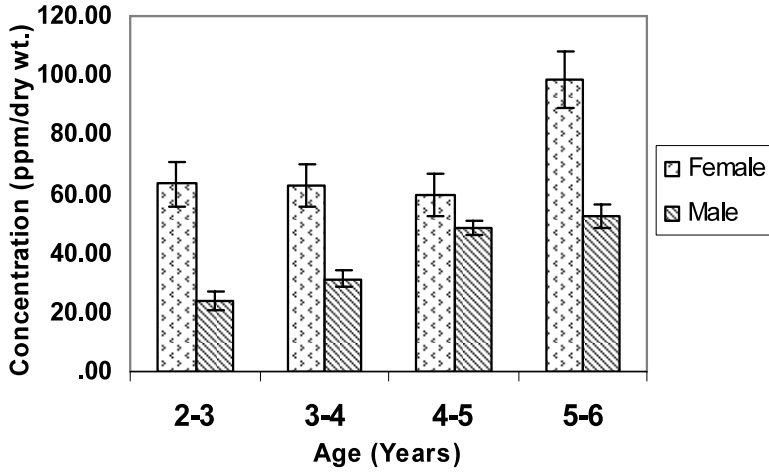


Fig. 4. Concentrations of zinc ions in liver.

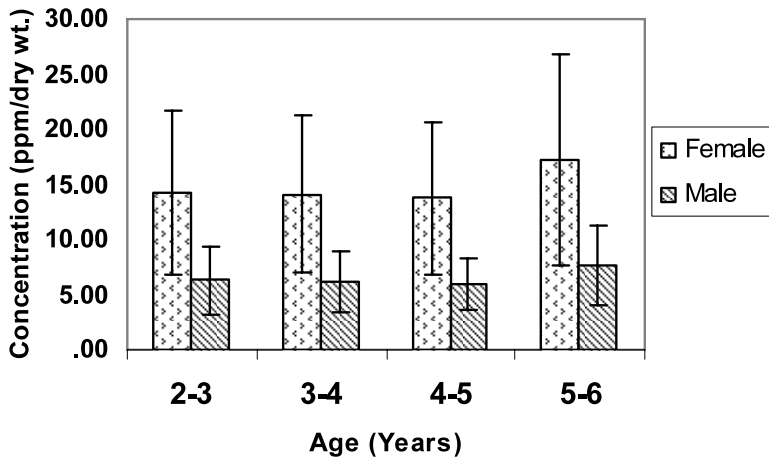


Fig. 5. Concentrations of lead ions in liver.

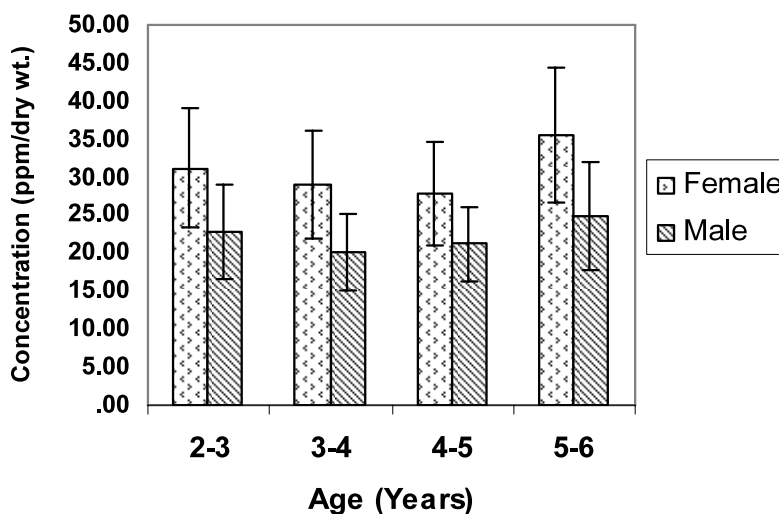


Fig. 6. Concentrations of zinc ions in kidney.

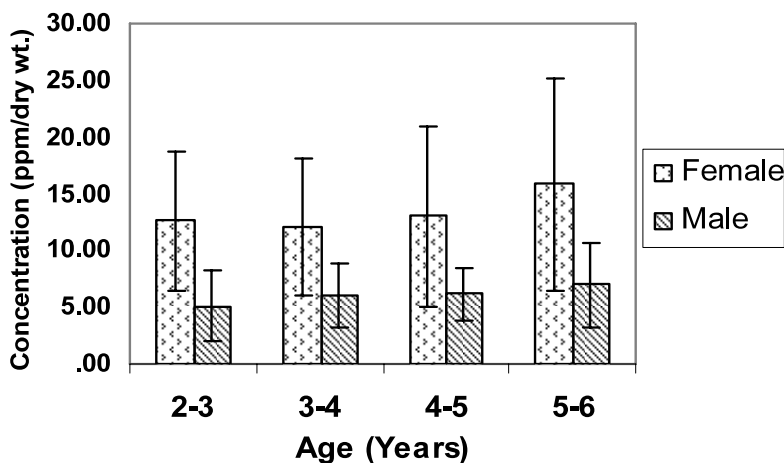


Fig. 7. Concentrations of lead ions in kidney.

In males, there was a significant ( $P < 0.1$ ) different concentration of zinc and lead in the livers and kidneys between fish of total length 25-28 cm (5-6 age classes) and 13-17 cm (2-3 age classes) (Figs. 4-7), but no significant difference was noticed regarding muscles (Figs. 2-3). Also, no significant difference ( $P > 0.5$ ) in lead concentrations in muscles, liver and kidneys was observed between the old fish 21-17 cm (3-4 age classes) and younger fish 13-17 cm (2-3 age classes), but there was a significant difference ( $P < 0.1$ ) in the concentration of zinc in the liver.

The highest concentration of zinc and lead occurred in the liver (Figs. 4-5). The muscles and kidney showed no significant difference ( $P > 0.1$ ) between males and females, but there was a significant difference ( $P < 0.1$ ) in their concentrations in the liver of both genders.

### Discussion

The accumulation of zinc and lead ions in muscles, liver and kidney were expressed in ppm/dry weight (Tables 1 and 2). The results obtained in the present study indicated that there was a significant difference ( $P < 0.1$ ) between the concentration of zinc and lead in the liver of female individuals with a length between 27-32 cm (5-6 age classes) and 18-21 cm (2-3 age classes). The results agreed with those reported by Patrick and Loutit [19]. The highest concentration of zinc (98.61 ppm/dry weight) could certainly be based on specific metabolism process and coenzyme catalyzed reactions taking place in liver [20]. It is known that low molecular weight zinc-binding legends (LMW-ZBL) are a key regulator for intestinal zinc absorption, possibly a carrier molecule across the intestinal mucosal cells. Some high molecular weight zinc-binding legends also appear to be involved in regulating intestinal zinc transport [21]. Similar results were obtained by Ashraf [22] in *Epinephelus microdan* fish from the Arabian Gulf. Eisler and Laroche [23] found that large specimens of *Fundulus heteroclitus* L. contained less zinc per unit weight than smaller ones. Similarly, in the whiting *Mertangus merlangus* L., the levels of zinc decreased with increased length and weight [24]. On the other hand, Cutshall *et al.* [25-26] reported that in the hake *Merluccius productus* L., a closely related species, the zinc content per unit weight in muscles increased with increased body weight. The present investigations showed a significant ( $P < 0.1$ ) increase in the zinc concentration between 27-32 cm (5-6 age classes) and 24-27 cm (4-5 age classes), but no significant ( $P > 0.5$ ) was noticed for lead.

It has been reported that metals other than mercury exhibit age-dependence in aquatic biota. They show either a decrease in or an unchanged concentration as organisms age; however, exceptions are known [27]. However, no correlation was reported between the zinc concentration in the muscles with both body lengths in the blue fish *Pomatomus saltatrix* L. [28]. In the present study, no significant ( $P > 0.5$ ) difference was noticed between the zinc and lead concentrations and age in the muscle of *L. limanda*.

Lead and zinc levels in the kidney of the tested samples range from 12.11 ppm to 15.83 ppm and 27.93 ppm to 35.52 ppm in females respectively and ranged from 5.12 ppm to 6.96 ppm and 20.13 ppm to 24.82 ppm in males respectively. Concentrations of 3.82 ppm and 47.73 ppm have been reported for lead and zinc respectively in the kidney of *E. microclan* [22]. Levels of zinc were lower in muscles compared with liver and kidneys of roach *Rutilus rutilus* L. [29]. In the present study, the accumulation of lead and zinc in the tested parts of *L. limanda* follows the following order: liver > muscles > kidney.

The effect of sex on an organism's capability to accumulate trace elements has been suggested to be mainly to either of two mechanisms: (a) the amount of pollutant lost during oviposition or reproduction may differ between sexes, therefore, females may be expected to exhibit smaller residues; (b) male and female individuals of a species differ in age-length relationships, hence the female may be expected to exhibit lower concentration of pollutants which is age-dependent for net accumulation [27]. This conflicts with the results obtained in the present study regarding tissues or organs of *L. limanda*.

### References

- [1] Forstner, U. and Wittmann, G.T.W. *Metal Pollution in the Aquatic Environment*. Berlin: Springer-Verlag, 1983, 486 p.
- [2] Freedman, B. *Environment Ecology: The Ecological Effects of Pollution, Disturbance, and Other Stresses*. 2<sup>nd</sup> ed., Canada: Academic Press, 1995.
- [3] Waldichuk, M. "Some Biological Concerns in Heavy Metal Pollution." In: F.J. Vernberg and W.B. Vernberg (Eds.), *Pollution and Physiology of Marine Organisms*. New York: Academic Press, 1974, pp. 1-57.
- [4] Laws, E.A. *Aquatic Pollution: A Widely-interscience Publication*. New York, Chichester, Brisbane and Toronto: John Wiley and Sons, 1981.
- [5] Bryan, G.W. "The Effects of Heavy Metals (Other than Hg) on Marine and Estuarine Organisms." *Proc. Roy. Soc. Lond.*, B 177 (1971), 389-410.
- [6] Van Hoff, V.D. and Van San, M. "Analysis of Cu, Zn, Cd, Cr in Fish Tissues: A Tool for Detecting Metal Caused Fish Kills." *Chemosphere*, 10 (1981), 1127-1135.
- [7] Gaspic, Z.K.; Zvonaric, T.; Vrgoc, N.; Odzak, N. and Baric, A. "Cadmium and Lead in Selected Tissues of Two Commercially Important Fish Species from the Adriatic Sea." *Water Research*, 36 (2002), 5023-5028.
- [8] Al-Yousuf, M.H.; El-Shahawi, M.S. and Al-Ghais, S.M. "Trace Metals in Liver, Skin and Muscle of *Lethrinus lentjon* Fish Species in Relation to Body Length and Sex." *The Science of the Total Environment*, 256 (2000), 87-94.
- [9] Canpolat, O. and Calta, M. "Heavy Metals in Some Tissues and Organs of *Capoeta capoeta-unbla* (Heckel 1843) Fish Species in Relation to Body Size, Age, Sex and Seasons." *Fresen. Environ. Bull.*, 12 (2003), 961-966.
- [10] Farkas, A.; Salanki, J. and Specziar, A. "Age and Size-specific Patterns of Heavy Metals in the Organs of Freshwater Fish *Abramis brama* L. Populating at Low Contaminated Site." *Water Research*, 37 (2003), 959-964.
- [11] Pourang, N. "Heavy Metal Bioaccumulation in Different Tissues of 2 Fish Species with regards to Their Feeding Habits and Trophic Levels." *Environ. Monit. Assess.*, 35 (1995), 207-219.
- [12] Watanabe, K.H.; Desimone, F.W.; Thiagarajah, A.; Hartley, W.R. and Hindrichs, A.E. "Fish Tissue Quality in the Lower Mississippi River and Health Risks from Fish Consumption." *Sci. Total Environ.*, 302 (2003), 109-126.
- [13] Allengil, S.M. and Martynov, V.G. "Heavy Metal Burdens in 9 Species of Freshwater and Anadromous Fish from the Pechora River, Northern Russia." *Sci. Total Environ.*, 161 (1995), 653-659.
- [14] Allengil, S.M.; Gubala, C.P.; Landers, D.H.; Lasorsa, B.K.; Creelius, E.A. and Curtis, L.R. "Heavy Metal Accumulation in Sediment and Freshwater Fish in U.S. Arctic Lakes." *Environ. Toxicol. Chem.*, 16 (1997), 733-741.
- [15] McCoy, C.P.; O'Hara, T.M.; Benett, L.W. and Boyle, C.R. "Liver and Kidney Concentrations of Zinc, Copper and Cadmium in Channel Catfish *Ictalurus punctatus*: Variations Due to Size, Season and Health Status." *Vet. Human. Toxicol.*, 37 (1995), 11-15.
- [16] Balu, S.M.; Myron, G.; Rami, J.K.; Bernardo, F.; Rao, D.J.V.P. and Khan, M.A.Q. "Temperature Enhancement of Heavy Metal Toxicity in Freshwater Invertebrates." *Toxicology*, 164 (2001), 211-211. Suppl. S.
- [17] Kische, M.A. and Machiwa, J.F. "Distribution of Heavy Metals in Sediments of Mwanza Gulf of Lake Victoria, Tanzania." *Environ. Int.*, 28 (2003), 619-625.

- [18] Krishnamurty, K.V.; Shpirt, S. and Keddy, M.M. "Trace Metal Extraction of Soil and Sediments by Nitric Acid-hydrogen Peroxide." *Atomic Absorption Newsletter*, 15, No. 3 (1976), 68-70.
- [19] Patrick, F.M. and Loutit, M.W. "Passage of Metals to Freshwater Fish from Their Food." *Water Res.*, 12 (1978), 395-398.
- [20] Jaffar, J. and Pervaiz, S. "Investigation of Multiorgan Heavy Trace Metals Content of Meat of Selected Dairy, Poultry, Fowl and Fish Species from Pakistan." *J. Sci. Indust. Res.*, 32 (1989), 175-177.
- [21] Song, M.K.. "Low-molecular Weight Zinc-binding Legend: A Regulatory Modulator for Intestinal Zinc Transport." *Comp. Biochem. Physiol.*, 87A, No. 2 (1987), 223-230.
- [22] Ashraf, W. "Accumulation of Heavy Metals in Kidney and Heart Tissues of *Epinephelus microdon* Fish from the Arabian Gulf." *Environ. Monit. Assess*, 101 (2005), 311-316.
- [23] Eisler, R. and Laroche, G. "Elemental Composition of the Estuarine Teleost *Pundulus heteroclitus* L." *J. Exp. Mar. Biol. Ecol.*, 9 (1972), 29-42.
- [24] Badsha, K.S. and Sainsbury, M. "Uptake of Zinc, Lead and Cadmium by Young Whiting in the Seven Estuary." *Mar. Poll. Bull.*, 8 (1977), 164-166.
- [25] Cutshall, N.H.; Naidu, J.R. and Percy, W.G. "Zin-65 Specific Activities in the Migratory Pacific Hake *Merluccius productus*." *Mar. Biol.*, 40 (1977a), 75-80.
- [26] Cutshall, N.H.; Naidu, J.R. and Percy, W.G. "Zinc and Cadmium in the Pacific Hake *Merluccius productus* of the Western U.S. Coast." *Mar. Biol.*, 44 (1977b), 195-202.
- [27] Phillips, D.J.H. *Quantitative Aquatic Biological Indicators*. London: Applied Science Publishers Ltd., 1980, 488 p.
- [28] Cross, F.A.; Hardy, L.H.; Jones, N.Y. and Barber, R.T. "Relation between Total Body Weight and Concentrations of Manganese, Iron, Copper, Zinc and Mercury in White Muscle of Blue Fish *Pomatomus saltatrix* and Bathyl Demersal Fish *Antimora rostrata*." *J. Fish Res. Bd. Canada*, 30 (1973), 1287-1291.
- [29] Badsha, K.S. and Goldspink, C.R. "Preliminary Observations on the Heavy Metal Content of Four Species of Freshwater Fish in New England." *J. Fish Biol.*, 21 (1982), 251-267.

**تراكم أيونات الرصاص والزنك في سمك *Limanda limanda* L. التي تم الحصول عليها من خليج مدينة سوانزي (جنوب ويلز، المملكة المتحدة)**

خليفة سليمان الخليفة

قسم العلوم، كلية المعلمين بمحافظة الرس،

الرس، المملكة العربية السعودية

(قدم للنشر في ١٠/١٠/١٤٢٧هـ؛ وقبل للنشر في ٢٠/١٠/١٤٢٧هـ)

**ملخص البحث.** عند دراسة مستويات عنصري الرصاص والزنك في أنسجة العضلات والكلى والكبد لسمك *Limanda limanda* L. التي جمعت من خليج مدينة سوانزي (جنوب ويلز) خلال شهر يوليو لعام ٢٠٠٦م والتي تم تعيينها بطريقة الامتصاص الذري للوزن الحاف، أظهرت النتائج تراكم عنصر الزنك بالطريقة التنازلية: الكلية > العضلات > الكبد وذلك في الذكور والإناث على حد سواء، بينما أظهرت النتائج تراكم عنصر الرصاص بالطريقة التنازلية: العضلات > الكلية > الكبد لجميع الأعمار من كلا الجنسين، وقد لوحظ أن تراكم عنصري الرصاص والزنك في العضلات والكبد والكلى في الإناث وصل تقريباً إلى مستوى الضعف مقارنة بالذكور من نفس العمر.