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Trace element concentrations in muscle tissue of the benthopelagic grenadier (*Coryphaenoides armatus*) from the Iberian deep-sea

Elementspurengehalte im Muskelgewebe des benthopelagischen Grenadiers (*Coryphaenoides armatus*) aus der Iberischen Tiefsee

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Abstract

11 specimens of *Coryphaenoides armatus* were collected at former dumping sites for radioactive material in the Iberian deep sea at a depth of 4700 m and their muscle tissue was analysed for four trace elements (copper, zinc, cadmium and lead) by differential pulse anodic stripping voltammetry (DPSAV). Concentrations of zinc were typical for fish muscle in general; copper content was somewhat higher than generally found in fish. The cadmium and lead contents were at a level found in fish from the open sea but the lead content of 2 specimens taken in area East-B was found to be higher.

Kurzfassung

11 Tiefseegrenadiere (*Coryphaenoides armatus*) wurden in einem ehemaligen Versenkungsgebiet für schwach radioaktive Abfälle in der Iberischen Tiefsee gefangen. Ihr Muskelgewebe wurde auf 4 Elementspuren (Zink, Kupfer, Cadmium und Blei) mit DPSAV untersucht. Die Gehalte an Zink waren für Fischmuskel typisch, der Kupfergehalt war höher als bei anderen Fischarten. Der Cadmium- und Bleigehalt war auf einem Niveau, was bei Fischen der offenen See typisch ist, lediglich der Bleigehalt von 2 Proben aus dem Gebiet Ost-B war erhöht.

Introduction

Only few data on trace element concentration are available for benthopelagic deep sea ocean fishes because of the difficulties of catching. More information is available for the grenadiers which are commercially fished and which are caught on the European continental slope and Rockall Trough as roundnose grenadier (*Coryphaenoides rupestris)*, rough-head grenadier (*Macrourus berglax*) Mediterranean grenadier (*Coryphaenoides mediterranea*) and spear-snouted grenadier (*Coelorhynchus labiatus*) (Cronin et al. 1998). There are only two references for the benthopelagic fish *Coryphaenoides armatus* (Windom et al. 1987; Cronin et al. 1998) in which trace metal concentrations in the muscle tissue of this species from the Atlantic and Pacific oceans are described. This abyssal grenadier is the only cosmopolitan rattail recorded from all oceans except the Arctic (Endo and Okamura 1992). A picture of the species and the distribution area can be found in the publication of Endo and Okamura, 1992. During the 274th cruise of the FRV "Walther Herwig III" for radioecological investigations in the former dumping site for weak radioactive disposals in the Iberian deep sea some specimen of *Coryphaenoides armatus* were collected and used foe trace element analysis. This former dumping site is about 700 km Northwest off the Spanish coast. It is located around the 46th degree of latitude from 16°00'W to 17°30'W and has an area of approximately 4300 km^2. The deepest parts reach a depth of >4700 m. From 1971 to 1982 in this area radioactive material was dumped from many countries in some 130 000 barrels with a total radioactivity of 35 Peta-Bequerel (35 x 1015 Bq) (Kanisch 2003).This area is generally low in biomass and the major representatives of fish are grenadiers (Macrouridae).

Material and Methods

Coryphaenoides armatus

The specimen of the deep sea grenadiers were collected in the working area B (rectangle 45°50' N, 17°30' W and 46°10' N, 16°00' W) and reference area East-B (rectangle 45°50' N, 13°15' W and 46°10' N, 12°45' W) during the 274th cruise of the FRV "Walther Herwig III" from 11.04.2005 to 01.05.2005. Main aim of this cruise was to investigate radioactivity in biota caught at the former dumping sites for radioactive disposals in Iberian deep-sea. The grenadier were caught using an self opening and closing Agassiz-trawl (3 m wide, 1 m high, 2.6 m length) which guaranteed that only bottom living and benthopelagic organisms were collected. Trawling time was 4 h at a trawling speed of 2 knots.

When brought onboard the grenadiers were taken directly from the Agassiz-trawl without contact to the ship and brought into the chemical laboratory where the muscle tissue was carefully dissected using titanium knives and scissors to avoid any contamination. The samples for later analysis at land were frozen in PE boxes to – 30 °C and stored at this temperature. Table 1 show details of the 11 specimen used for the analyses.

Sample treatment

All frozen samples were lyophilised in a Finn-Aqua Lyovac GT 2 freeze dryer (parameters: ambient temperature 15 – 25°C, vacuum 5–10 Pa, duration at least 48 h) and finally finely milled in a ball mill made from agate (Planetary Ball Mill, Fritsch, Pulverisette 5, Idar-Oberstein, Germany).

After milling, all samples were kept in high-density polyethylene bags at room temperature in an exsiccator until mineralisation.

Lyophilised milled samples (approximately 0.4 g) were weighed into petri dishes which were put in a low-temperature microwave activated oxygen plasma processor (Plasma Prozessor 200-G, Technics Plasma, München, Germany) for mineralisation (power supply 350–360 W, vacuum 60–90 Pa, oxygen partial pressure 2.0–2.5_105 Pa); the duration of decomposition was 144–168 h. The decomposed

Table 1: Code no, date of catch, area, position, depth, length, and weight of deep sea grenadier (*Coryphaenoides armatus*) specimen investigated. n.d. (not determined).

Tabelle 1: Code, Fangdatum, Bereich, Position, Fangtiefe, Länge und Gewicht der untersuchten Tiefseegrenadiere (Coryphaenoides armatus), n.d. (nicht bestimmt).

Code no	Date	Area	Position	Depth [m]	Length [cm]	Weight [g]
1	20.04.2005	Working area B	46°09,82'N 017°21,94'W	4690	55	1280
2	20.04.2005	Working area B	46°09,82'N 017°21,94'W	4690	68	1360
3	20.04.2005	Working area B	46°09,82'N 017°21,94'W	4690	58	920
4	20.04.2005	Working area B	46°09,82'N 017°21,94'W	4690	65	1840
5	21.04.2005	Working area B	46°07,53'N 017°17,54'W	4700	67	2400
6	21.04.2005	Working area B	46°07,53'N 017°17,54'W	4700	70	2140
7	21.04.2005	Working area B	46°07,53'N 017°17,54'W	4700	64	1720
8	21.04.2005	Working area B	46°07,53'N 017°17,54'W	4700	58	1100
9	21.04.2005	Working area B	46°07,53'N 017°17,54'W	4700	65	1180
10	24.04.2005	Reference area East B	46°01,53'N 013°10,29'W	4784	n.d.	n.d.
11	24.04.2005	Reference area East B	46°01,53'N 013°10,29'W	4784	n.d.	n.d.

samples were quantitatively transferred into 100 ml volumetric flasks and dissolved in Suprapure sulphuric acid (0.2 %, w/w) at pH 2.

Voltammetry

In this study, DPSAV (746 VA Trace Analyser, Metrohm, Switzerland) equipped with autosampler (695 VA Autosampler, Metrohm, Switzerland) was used for the determination of heavy metals. Exact experimental conditions and the methods used for analytical quality assurance for the determination of cadmium and lead are given by Celik et al. 2004a and for copper and zinc by Celik et al. 2004b.

Results and Discussion

The results of the analyses of the four elements are presented in Table 2. All muscle tissues of the deep sea grenadier exhibit a high content of water. Based on the average dry matter of about 17 % the muscle tissue contains 83 % of water which is very close to the average of 83,7 % reported for white skeletal muscle of Coryphaenoides armatus collected in Gulf of Mexico at depth between 1885 to 4815 m, Siebenaller et al. 1992. The zinc content at a level of 3 mg/kg wet weight is typical for the muscle tissue of fish in general (Oehlenschläger 1997) and the deep sea grenadier contains the same amount as most other species. The copper content of 0.1 mg/kg wet weight is similar to the content reported by Windom et al. 1987 with 0.13 mg/kg in *C. armatus* which was caught in traps at a depth of 2500 m in the North Atlantic (41°45'N, 65°00'W). The copper content, however, is higher than found in most other species where the copper content in muscle tissues varies from 0.2 mg/kg wet weight to 0.9 mg/kg wet weight with an average of approximately 0.3 mg/kg (Oehlenschläger 1997). There is no difference in the zinc and copper concentrations in specimen from area B and area East-B.

Concerning the two toxic heavy metals cadmium and lead there is no difference in cadmium concentrations of specimen from area B and area East-B but the lead content in specimen from area East-B is 2-3fold higher (16.5 µg/kg) than the lead content in specimen from area B (5.5 µg/kg). A comparison with the values found by Windom et al. 1987 reveals that these authors have found a higher cadmium content (4.59 µg/kg and 1.73 µg/kg, respective) but a lower lead content (2.04 µg/kg and 7.55 µg/kg, respective). If this difference is based on environmental factors, pollution from dumped material or

Table 2: Dry matter, cadmium, lead, zinc and copper content in muscle tissue of deep sea grenadier (*Coryphaenoides armatus*), code no of specimen correspond to code no of specimen in Table 1, for comparison purpose the concentrations reported in Windom et al. 1987 and Cronin et al. 1998 are added at the end of the table.

Tabelle 2: Trockensubstanz, Cadmium, Blei, Zink und Kupfergehalt im Muskelgewebe von Tiefseegranadieren (Coryphaenoides armatus), der Code für die Einzeltiere entspricht dem in Tabelle 1, zum Vergleich sind die von anderen Autoren (Windom et al. 1987 und Cronin et al. 1998) gefundenen Konzentrationen am Tabellenende beigefügt.

Code No	Dry matter [%]	Cd [µg/kg wet weight]	Pb [µg/kg wet weight]	Zn [mg/kg wet weight]	Cu [mg/kg wet weight]
1	17,08	2,4	10,2	4,4	0,11
2	17,02	3,4	5,7	3,2	0,14
3	17,66	1,2	6,4	2,6	0,13
4	16,04	1,5	8,3	2,5	0,12
5	15,91	0,7	4,0	2,6	0,14
6	15,63	1,6	4,3	2,6	0,12
7	17,12	0,8	2,9	2,7	0,09
8	17,36	1,4	3,8	2,6	0,10
9	17,68	0,9	4,6	2,8	0,09
10	18,25	3,6	17,5	3,6	0,13
11	17,06	1,5	15,4	3,0	0,09
Mean ± SD		1,73 ± 0,99	7,55 ± 4,90	2,96 ± 0,58	0,10 ± 0,05
Mean Windom et al. 1987		4,59	2,04		0,13
Median Cronin et al. 1998		10	170	4,4	0,31

on different feed cannot be decided. Macrouridae are generalist feeders on a wide variety of benthic and benthopelagic organisms, which was reported for *C. armatus* caught not far from our sampling site at 47°N, 20°W at a water depth of 4500 m (Martin und Christiansen 1997). Cronin et al. 1998 mentioned that the diet of *C. armatus* consists mainly of crustaceans, especially copepods and amphipods. Cronin et al. 1998 reported quite similar concentrations for copper and zinc in some specimen caught at a depth of 2887 m in Rockall Trough. However, the concentrations of cadmium and lead in the fish from Rockall Trough exceeded the concentrations found in the specimen from Iberian deep sea by far (10 µg/kg for cadmium and 170 µg/kg for lead).

With the exception of the lead concentrations in the specimen from area East-B, the cadmium and lead concentration in the samples from the Iberian deep-sea are as low as found in other fish species commercially fished in North-Atlantic waters (Celik et al. 2004a; Oehlenschläger 2002).

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