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Natural trace element enrichment in fishes from a volcanic and tectonically active region (Azores archipelago)

Joana Raimundo [a,*], Carlos Vale [a], Miguel Caetano [a], Eva Giacomello [b], Bárbara Anes [a], Gui M. Menezes [b]

[a] IPMA Instituto Português do Mar e da Atmosfera, Av. Brasília, 1449-006 Lisboa, Portugal
[b] Centro do IMAR da Universidade dos Açores, Departamento de Oceanografia e Pescas & Laboratório Associado LARSyS, Rua Prof. Frederico Machado no. 4, 9901-862 Horta, Faial, Açores, Portugal

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ABSTRACT

Seamounts, in general, are thought to support high biodiversity and special biological communities. They have been targeted by commercial fishing for demersal and pelagic fish species due to the occurrence of large aggregations in mid- and deep-water. Specimens of *Phycis phycis*, *Helicolenus dactylopterus*, *Pontinus kuhlii*, *Beryx splendens*, *Beryx decadactylus*, *Etmopterus pusillus*, *Mora moro*, *Pagellus bogaraveo*, *Deania profundorum*, *Scomber colias* and *Trachurus picturatus* were collected at the Condor seamount and on the slopes of Faial and Pico islands of Azores archipelago. Concentrations of V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Cd and Pb were determined in muscle and liver of each individual. Values of the 11 trace elements in the two tissues of the benthopelagic and benthic specimens, from the two surveyed areas, presented a significant inter-specific variation. In general, levels were lower in muscle than in liver, and negative relations between weight and Co, Mn, Zn, As, Cd and Pb concentrations in muscle and liver of three species were found. *Pagellus bogaraveo, S. colias* and *T. picturatus* presented enhanced elemental concentrations in liver, particularly of Cd. The extremely high storage of this potentially toxic element suggests a response to high uptake of Cd and the existence of an additional natural source of Cd to the environment.

1. Introduction

Trace elements are widely distributed in the Ocean, reflecting chemical equilibria in the water, as well as exchanges with the sediment and atmosphere (Libes, 1992). Trace elements derived from weathering and human activities are added to the coastal environment mainly through rivers and estuaries, atmosphere and sewage pipes (Bryan et al., 1985; Herut and Kress, 1997). Hydrothermal activities in the seafloor have also been recognized as important natural sources of trace elements in volcanic regions (Charlou et al., 2000; Douville et al., 2002), and such sources occur on the Mid-Atlantic Ridge (MAR) off the Azores Archipelago where several important hydrothermal vents have been identified (Cannat et al., 1999; Rona et al., 1986).

Concentrations of essential and non-essential elements in marine organisms reflect primarily metabolic mechanisms to meet requirements of individuals, as well as response to their availability in food and environment. For example, Cu and Zn are known as vital components of enzymes, respiratory proteins and certain structural elements (Depledge and Rainbow, 1990); Mn, Se and Co have important roles in various cellular components like pyrovate carboxylase, glutathione peroxidase and vitamin B12, respectively. Other elements like Cd and Pb are considered as non-essential, since no biological role was identified, and these elements have toxic effects when associated with metabolically active sites (Rainbow, 1985). The uptake of trace elements by marine organisms can occur via water, suspended particulate matter, food and sediments (Valavanidis et al., 2006).

Trace element concentrations in deep sea demersal fishes were reported previously (e.g., Carvalho et al., 2005; Dural et al., 2010; Türkmen et al., 2009) and in species living near hydrothermal vents (Company et al., 2010; Kádár et al., 2007; Martins et al., 2006). Higher metal concentrations in deep-sea fish captured near the MAR than in the same species from other environments (Company et al., 2010; Martins et al., 2006). Several metabolic mechanisms and life history strategies of organisms living in metal-rich environments have been proposed as explanatory factors (e.g. Bebianno et al., 2005; Company et al., 2008; Cunha et al., 2008).

The Azores region lies above a volcanic and tectonically active seafloor, rich in hydrothermal activity spots and seamounts, which support high biodiversity, special biological communities, such as deep-water corals and sponges, and important fishing grounds for both demersal and pelagic fisheries (Menezes et al., 2009; Morato et al., 2010; Rogers, 1994; Rowden et al., 2010; Tempera et al., 2012). The Condor Seamount, located to the SW of the central Azores Islands Faial and Pico is a traditionally important fishing ground for the local demersal fishery (Menezes et al., 2013).

* Corresponding author.
E-mail address: jraimundo@ipma.pt (J. Raimundo).

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The current work presents an inventory of the 11 trace element concentrations in 11 benthopelagic and benthic species captured at the Condor Seamount and in the slopes of two Azores islands from the central group (Faial and Pico). Trace element concentrations in muscle and liver are compared between species, habitats and areas of capture. The relevance of metal volcanic sources and the possible impact in the fish tissues concentrations is also investigated. Variations of element concentration between and within species were also investigated in relation to biological parameters and trophic level.

2. Material and methods

2.1. Samples

Benthic and benthopelagic specimens were captured during a scientific longline survey in Spring 2010 at the Condor Seamount (Condor) and near Faial and Pico islands (Faial-Pico), Azores (Fig. 1). The following species were analyzed: *Phycis phycis*, *Helicolenus dactylopterus*, *Pontinus kuhlii*, *Beryx splendens*, *Beryx decadactylus*, *Etmopterus pusillus*, *Mora moro*, *Pagellus bogaraveo*, *Deania profundorum*, *Scomber colias* and *Trachurus picturatus*. All specimens were weighed, measured (fork or total length) and sexed (Table 1). Specimens were dissected immediately after capture, and muscle (without skin) and liver were removed and frozen (−18 °C) until analysis. Additional information on habitats, depth of occurrence, and trophic level for each species (Table 1) was obtained from other studies. The species were assigned to either of two Habitats, i.e. benthic or benthopelagic, on the basis of available information on vertical distribution of catches during longline surveys conducted in the Azores (Melo, 1997), and, when that was not possible, following Compagno et al. (2005). Weighted median and range of depth of occurrence were obtained from Menezes (2003), and trophic levels by Colaço et al., (2013).

2.2. Analytical methodology

Trace elements were analyzed in lyophilized, grinded and homogenized samples after digestion with a mixture of HNO_3 (sp, 65% v/v) and H_2O_2 (sp, 30% v/v) at different temperatures according to the

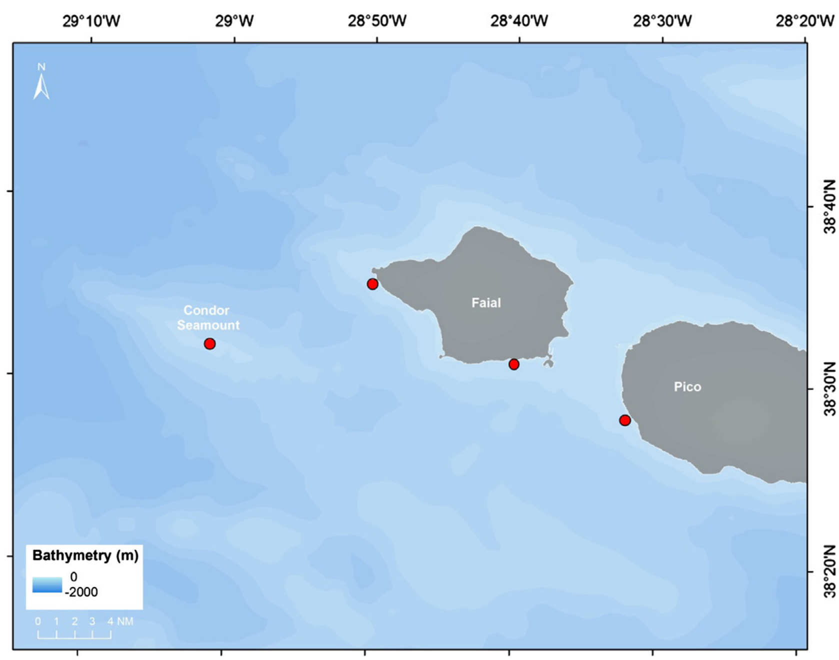

Fig. 1. Sampling areas at Condor seamount and Faial and Pico Islands. R. Medeiros©ImagDOP.

Table 1
Number of individuals (n), morphometric data and male-female (and hermaphrodites) number of the 11 fish species captured in Condor and Faial-Pico; data on habitat, median weighed depth (and range), and trophic level are also reported.

Species	Common name	n	Length (cm)	Weight (kg)	Male–female	Habitat	Depth (m)	Trophic level
Chondrichthyes								
Deania profundorum	Arrowhead dogfish	7	69–90[a]	1.1–2.4	4-3	Benthic	808 (411–1135)	4.1
Etmopterus pusillus	Smooth lanternshark	6	27–40[a]	0.14–0.37	2–4	Benthic	761 (206–1164)	3.9
Osteichthyes								
Beryx decadactylus	Alfonsino	9	22–49[b]	0.26–2.1	4–5	Benthopelagic	564 (270–723)	4.0
Beryx splendens	Splendid alfonsino	7	24–27[b]	0.31–0.45	3–4	Benthopelagic	382 (117–709)	3.8
Helicolenus dactylopterus	Bluemouth	7	25–40[a]	0.31–0.45	3–4	Benthic	390 (112–709)	3.9
Mora moro	Common mora	8	50–60[a]	1.6–4.8	2–6	Benthic	919 (374–1177)	4.3
Pagellus bogaraveo	Blackspot seabream	9	25–41[b]	0.27–1.4	4-1 (4)	Benthopelagic	323 (71–629)	3.8
Phycis phycis	Forkbeard	6	59–61[a]	0.40–3.9	4-2	Benthic	173 (25–573)	4.2
Pontinus kuhlii	Offshore rockfish	7	24–29[a]	0.20–0.83	3–4	Benthic	227 (61–582)	3.9
Scomber colias	Atlantic chub mackerel	5	27–38[b]	0.33–0.66	3-2	Benthopelagic	219 (31–975)	3.7
Trachurus picturatus	Blue jack mackarel	8	17–35[b]	0.060–0.49	2–6	Benthopelagic	181 (33–476)	3.7

[a] Total length.
[b] Fork length.