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Influence of the submarine volcanic eruption off El Hierro (Canary Islands) on the mesopelagic cephalopod's metal content

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ABSTRACT

This work investigates whether a submarine volcanic eruption off El Hierro (Canary Islands) in October 2011 influenced the metal contents of two deep water cephalopod species: *Abraliopsis morisii* and *Pyroteuthis margaritifera*. This was assessed by comparing metal contents in specimens collected off the island of El Hierro and in the neighbouring islands of La Palma and Tenerife during an experimental deep water fishing trip. The concentration of 20 heavy metals was analyzed in 180 specimens of A. morisii and *P. margaritifera* collected around the three islands to test for inter-island differences for each species and metal. While both species showed geographical differences in metal concentrations, the main finding was that A. morisii could be a bioindicator species for metals such as Li, Sr and Ca.

1. Introduction

The most important oceanic zone for fishing mesopelagic species in the Canary Islands is that associated with the deep reflection layer, which appears due to differences in density derived from the presence of the thermocline and causes a dense and stratified concentration of these mesopelagic organisms (Caldentey and Bordes Caballero, 2011; Von Dassow and Collado-Fabbri, 2014; Røstad et al., 2016). The waters of the Canary Islands are oligotrophic but as in all major outcrop regions, and the African upwelling "northwest African Upwelling" has a major influence on the oceanography of the Canary Islands (Auger et al., 2015; Davenport et al., 2002; Marcello et al., 2011).

The control of underwater volcanic activities is paramount for monitoring the chemistry of the oceans, where a large amount of material is injected into the medium, which may or may not be harmful to marine ecosystems (Baker et al., 2008; Carey et al., 2016). The most volatile magmatic phases act as transport agents of the magmatic-hydrothermal systems (Heinrich, 2005). Numerous studies on fluids associated with mineral deposits from underwater eruptions show an enrichment of metals such as Au, Cu, Ag and Mo. The behavior of these metals is limited by their solubility in volatile magmatic phases in equilibrium with the silicate formations (Simon et al., 2006; Zajacz et al., 2008; Frank et al., 2011; Park et al., 2016). Li is also found in high concentrations and is due to leaching from sediments at high fluid temperatures (James and Palmer, 2000; Nishio et al., 2015).

One of the study areas of this work was La Restinga on the island of El Hierro. The volcanic eruptions between October 2011 and March 2012 created an underwater volcano 86 m from the surface 2 km from the coast of El Hierro. The name of this new volcano is "Tagoro". The ejected materials behaved like oceanic tracers and were found in an area stretching from the eruption site to the open sea using remote sensing techniques and processing the effect of the turbidity. These eruptions are some of the most studied volcanic events in the Canaries, and, unlike eruptions occurring on land, underwater eruptions have a special feature because many of the materials and gases emitted greatly alter the oceanographic properties of the water column (Fraile-Nuez

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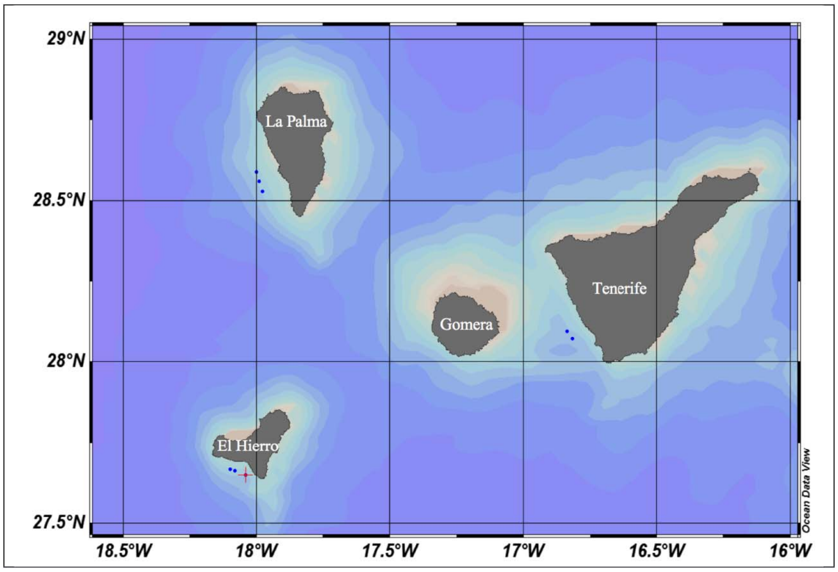

Fig. 1. Fishing areas in the Canary Islands.

Table 1
Means, minimum, maximum and standard deviation weights (g).

	El Hierro		Tenerife		La Palma	
	A. morisii	*P. margaritifera*	*A. morisii*	*P. margaritifera*	*A. morisii*	*P. margaritifera*
Female	2.99 ± 0.49	2.99 ± 0.80	2.63 ± 0.34	2.49 ± 0.39	2.91 ± 0.64	3.02 ± 0.54
Ind.	1.31 ± 0.31	1.33 ± 0.29	1.29 ± 0.35	1.19 ± 0.23	1.49 ± 0.40	1.36 ± 0.23
Male	2.93 ± 0.67	2.74 ± 0.15	2.64 ± 0.49	2.58 ± 0.34	2.50 ± 0.46	2.69 ± 0.27
Max.	4.52	4.70	3.23	3.18	3.95	4.27
Min.	1.12	1.12	1.00	1.01	1.23	1.19
Mean	2.41 ± 0.52	2.35 ± 0.50	2.19 ± 0.39	2.09 ± 0.32	2.30 ± 0.82	2.36 ± 0.39

Table 2
Mean concentration and standard deviation of heavy metals (mg/kg).

	El Hierro						Tenerife						La Palma					
	A. morisii			*P. margaritifera*			*A. morisii*			*P. margaritifera*			*A. morisii*			*P. margaritifera*		
Al	3.355	±	2.773	7.811	±	9.317	4.330	±	2.172	2.439	±	1.025	3.932	±	2.413	2.858	±	1.076
B	0.636	±	0.372	1.053	±	0.655	1.298	±	0.55	1.305	±	0.496	0.645	±	0.739	0.515	±	0.501
Ba	0.584	±	0.528	1.253	±	0.888	1.051	±	0.917	0.47	±	0.328	0.927	±	1.269	0.406	±	0.251
Ca	141	±	48.778	316.119	±	242.757	272.685	±	193.649	189.102	±	74.449	151.91	±	94.202	166.763	±	94.764
Cd	1.57	±	0.529	0.978	±	0.278	2.284	±	1.066	1.025	±	0.351	1.946	±	0.837	1.423	±	0.957
Co	0.036	±	0.014	0.026	±	0.01	0.045	±	0.025	0.02	±	0.007	0.036	±	0.027	0.016	±	0.013
Cr	1.942	±	2.368	0.542	±	0.379	0.533	±	0.328	0.406	±	0.244	0.411	±	0.401	0.313	±	0.216
Cu	2.762	±	0.921	5.978	±	8.65	5.707	±	2.854	3.954	±	1.776	3.469	±	2.571	5.619	±	2.412
Fe	14.755	±	8.932	11.895	±	8.49	23.109	±	13.311	11.511	±	6.263	13.414	±	13.106	9.697	±	5.486
K	338.817	±	183.846	250.952	±	85.085	428.042	±	163.685	329.347	±	155.794	205.735	±	130.666	138.487	±	83.967
Li	1.674	±	1.674	1.515	±	2.03	1.143	±	1.525	1.639	±	1.327	0.625	±	0.616	1.348	±	1.377
Mg	353.965	±	137.799	349.564	±	111.152	462.438	±	163.438	354.322	±	135.433	268.006	±	146.489	323.508	±	162.362
Mn	0.258	±	0.139	0.361	±	0.197	0.259	±	0.231	0.273	±	0.112	0.269	±	0.206	0.289	±	0.188
Mo	0.093	±	0.037	0.127	±	0.053	0.08	±	0.038	0.104	±	0.047	0.103	±	0.062	0.14	±	0.151
Na	840.884	±	313.519	894.93	±	250.048	819.97	±	291.929	812.497	±	291.539	564.847	±	252.229	341.16	±	163.489
Ni	0.519	±	0.73	0.456	±	0.2	0.414	±	0.203	0.684	±	0.428	0.26	±	0.157	0.341	±	0.202
Pb	0.908	±	0.449	1.471	±	1.125	1.199	±	1.277	0.629	±	0.388	1.128	±	1.427	0.524	±	0.505
Sr	2.195	±	0.754	5.486	±	262.961	3.585	±	2.308	2.846	±	1.002	2.353	±	1.279	2.46	±	1.322
V	0.036	±	0.046	0.061	±	0.098	0.685	±	0.274	0.335	±	0.288	0.236	±	0.239	0.188	±	0.159
Zn	9.657	±	3.247	13.83	±	8.947	12.068	±	5.138	10.361	±	3.395	9.792	±	4.543	11.357	±	4.376

et al., 2012; Ibáñez et al., 2012) and increase the concentration of heavy metals (Channing, 2003; Oosterbaan, 2016; Rubin, 1997).

Heavy metals are considered one of the major anthropogenic pollutants in coastal areas around the world (Ruilian et al., 2008). These metals pose a serious problem for the health of humans, marine organisms and ecosystems health, because of their toxicity, persistence and bioaccumulation. Pollution of the environment with toxic metals and radionuclides arises as a result of human activities, mainly industrial, but sources such as agriculture and waste disposal also contribute to this (DeForest et al., 2007). Many of these metals are known to be toxic or carcinogenic to humans, and can contribute to the degradation of marine environments by reducing the diversity of organisms (Hosono et al., 2011).

The concentration of metals in cephalopods is well documented