

True Seals as Bioindicators of Rare Earth Element Accumulation in Arctic Marine Food Webs

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The ongoing global energy transition has increased demand for Rare Earth Elements (REEs) used in strategic sectors such as renewable energy and digital technologies. However, there is limited understanding of REEs' trophic transfer and toxicological effects on marine ecosystems. This study investigates REE concentrations in four seal species: the harp seal (*Pagophilus groenlandicus*), hooded seal (*Cystophora cristata*), ringed seal (*Pusa hispida*), and bearded seal (*Erignathus barbatus*) from the Greenland Sea and Svalbard, serving as bioindicators for marine pollution. We quantified seven REEs (La, Nd, Eu, Gd, Tb, Dy, Er) in freeze-dried muscle and liver tissues (63 muscle and 72 liver), which were digested via Microwave Labstation ETHOS D and analyzed using Inductively Coupled Plasma–Mass Spectrometry (ICP-MS). All REEs were found in both tissues, with total REE concentrations (\sum REEs) ranging from 1 to 530 ng.g⁻¹ dw. Concentrations were the highest for La and Nb followed by Gd, Dy and Eu, in all samples. In Greenland seals La concentrations were slightly higher than Nb. In Svalbard seals La and Nb concentrations did not differ. Liver tissue levels were approximately 40 times higher than the levels in muscle. No regional differences were observed between the Greenland Sea and Svalbard. However, ringed seals from all locations exhibited significantly lower liver \sum REEs than the other three species. Similarly, within the Greenland Sea muscle \sum REEs were lower in ringed seals compared to harp and hooded seals, which may indicate regional variations in environmental REE distribution. Comparison with previously published data from Nunavik, Canada showed that REEs in ringed seal liver samples from Svalbard, East Greenland and Nunavik are at the similar range, whereas bearded seals from Svalbard presented a lower range of liver \sum REEs (88.8 - 501 ng.g⁻¹ dw) than those from Nunavik (130 - 880 ng.g⁻¹ dw). \sum REEs measured in Arctic seal liver samples were slightly higher than those measured in the Southern North Sea, whereas an opposite pattern was seen for muscle. The varying bioaccumulation of REEs between muscle and liver suggests seasonal exposure differences. These findings highlight that REE bioaccumulation in Arctic seals is influenced by numerous ecological and environmental factors, emphasizing the need to monitor these pollutants in Arctic marine ecosystems.