

# Sulfur Isotopes $\delta^{34}\text{S}$

Sulphur is present in nearly all natural environments.

An essential component of living cells, constituting around 0.5–1.0% (dry mass) of prokaryotic organisms; lower concentration in collagen (0.2%).

Occurs throughout the biosphere in organic substances, in marine waters and sediments as both sulfide ( $\text{S}^{2-}$ ) and sulfate ( $\text{SO}_4^{2-}$ ).

Sulphate-reducing organisms are widely distributed in anoxic environments containing sulfate and, as a group, they have a broad ecological tolerance.

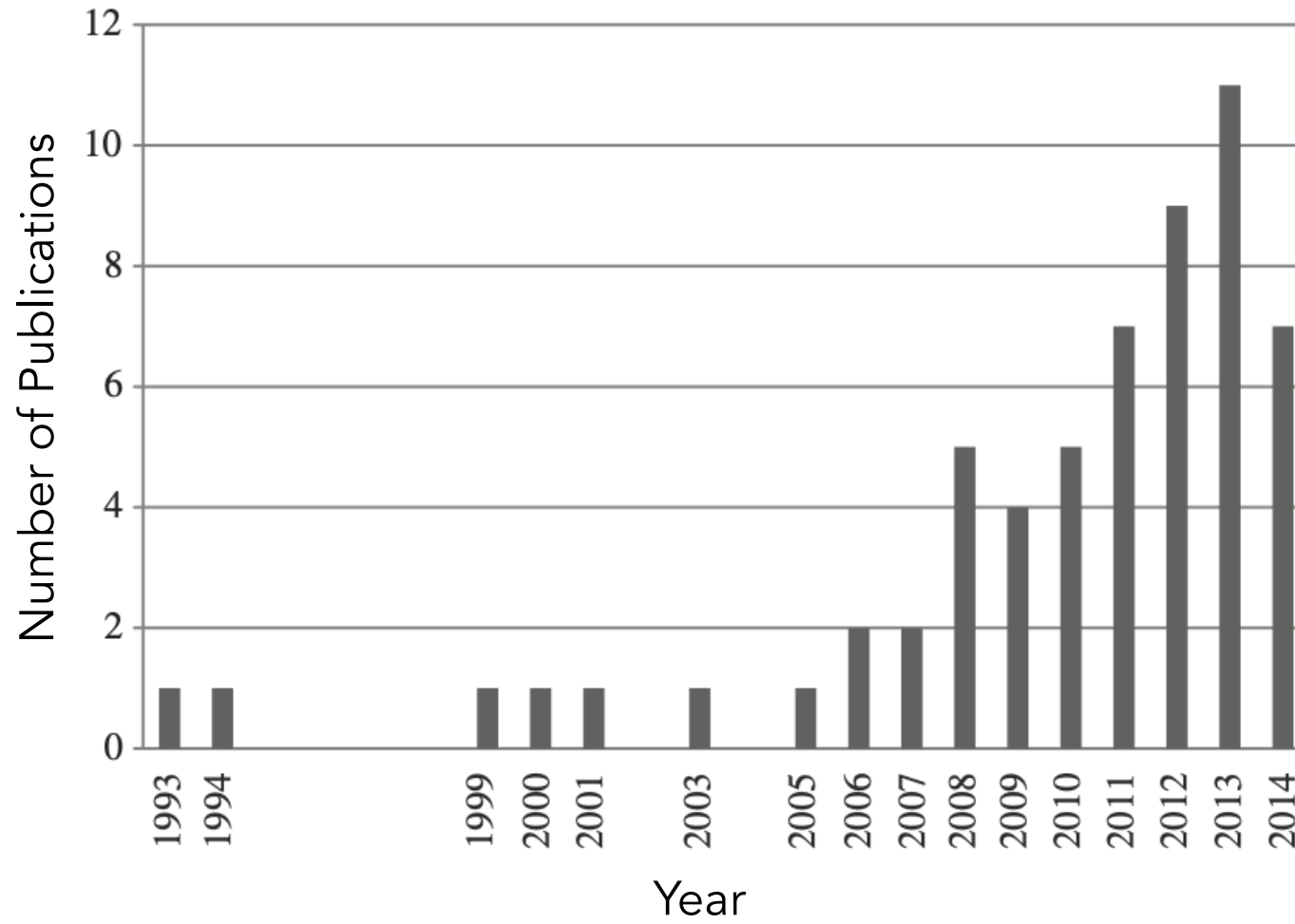


Canyon Diablo Triolite (Meteorite)

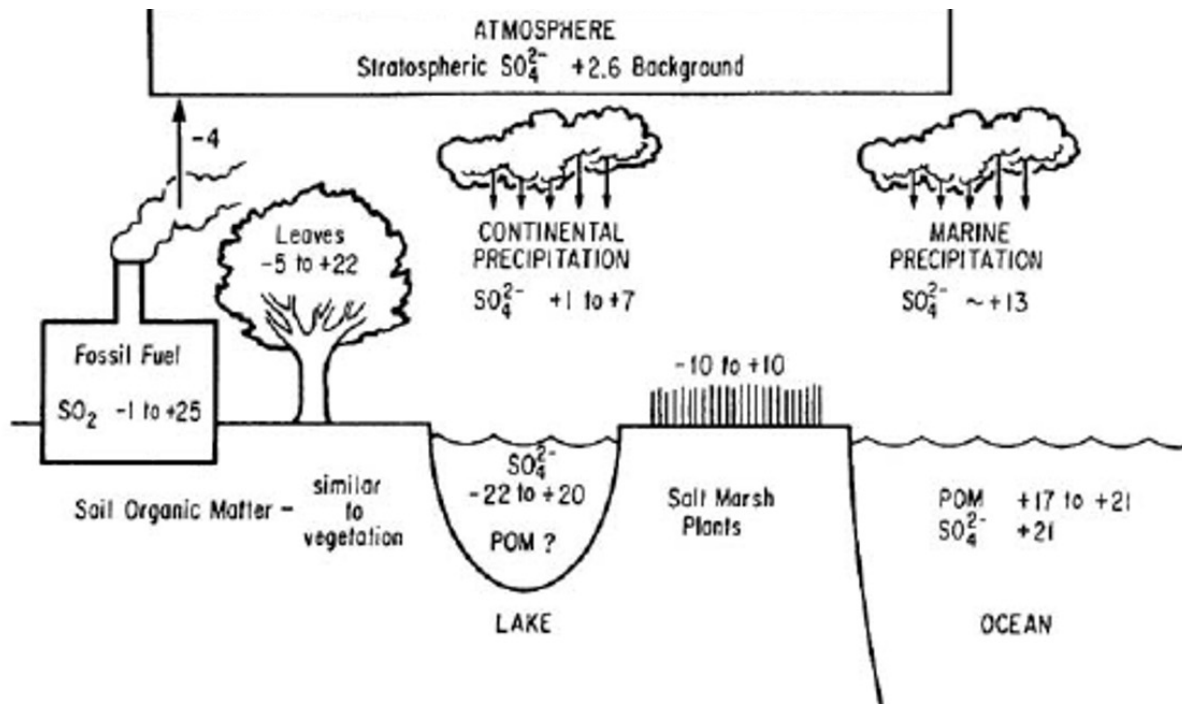
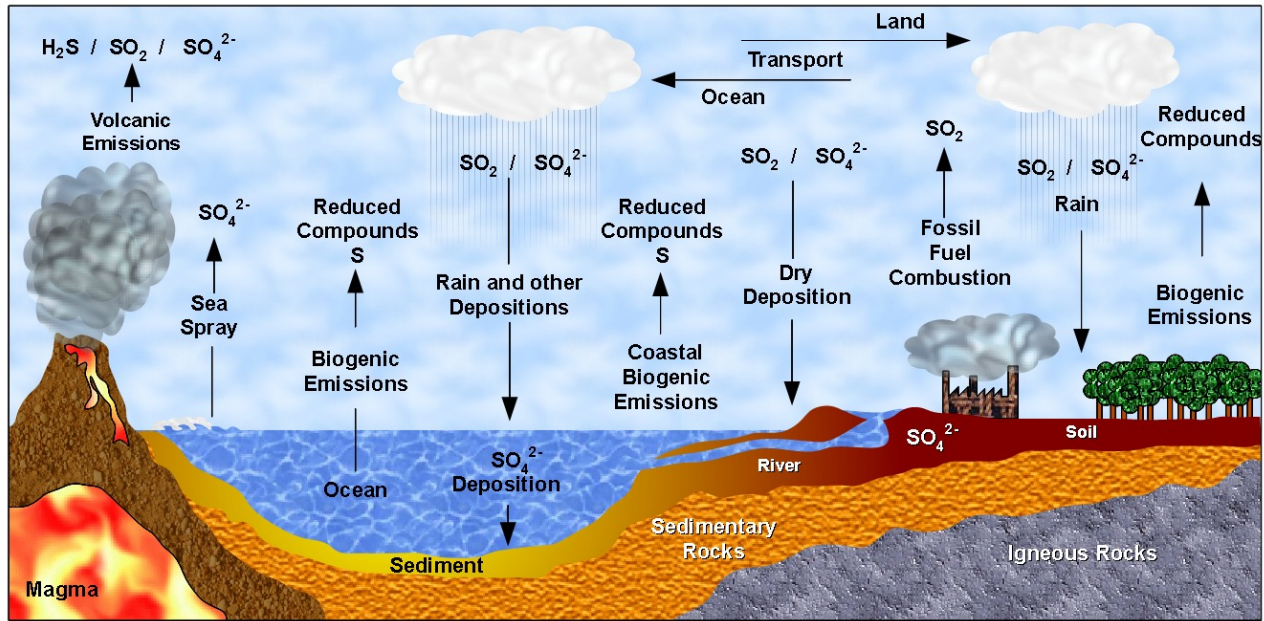


Meteor Crater, Arizona

# $\delta^{34}\text{S}$ is Trending



# The Sulfur Cycle

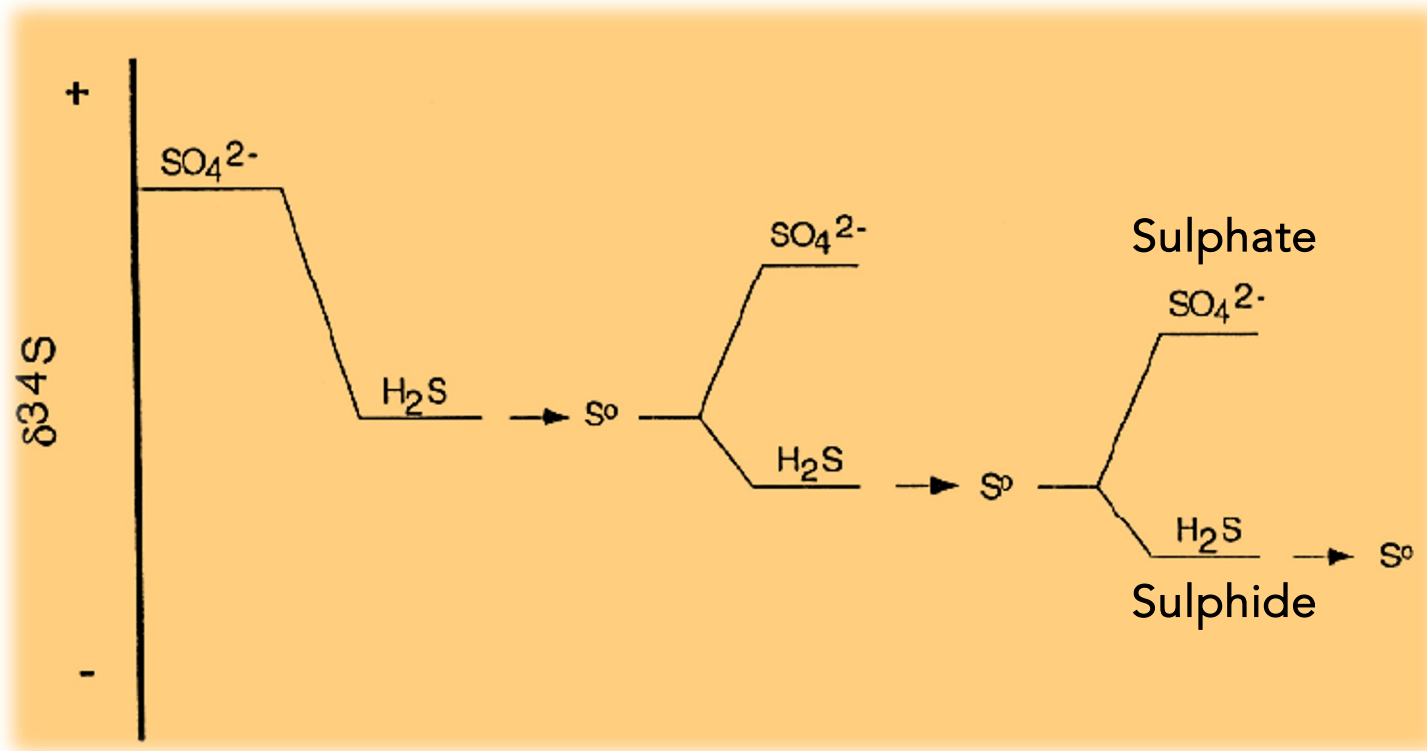


# The Influence of Bacteria

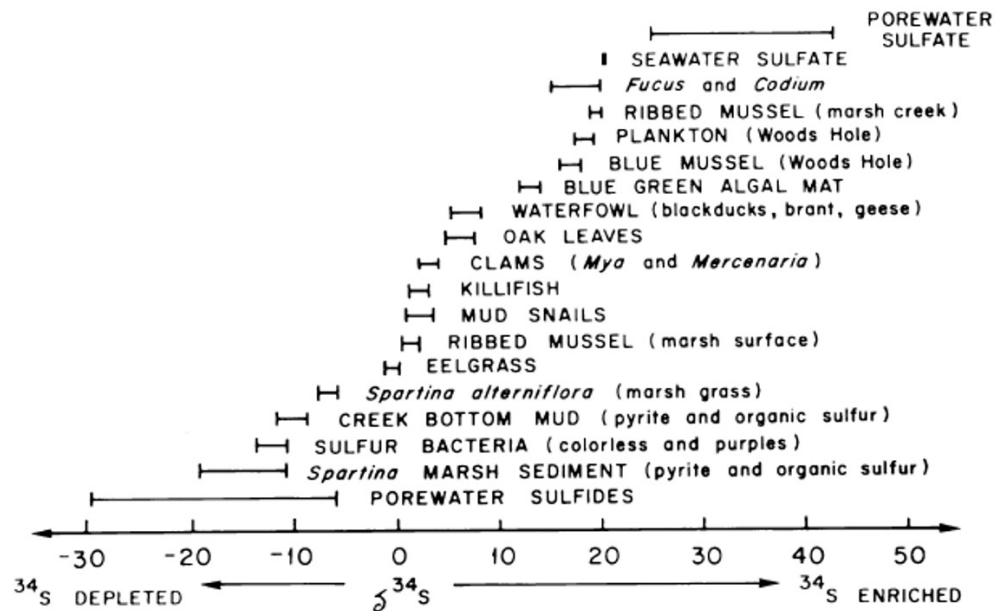
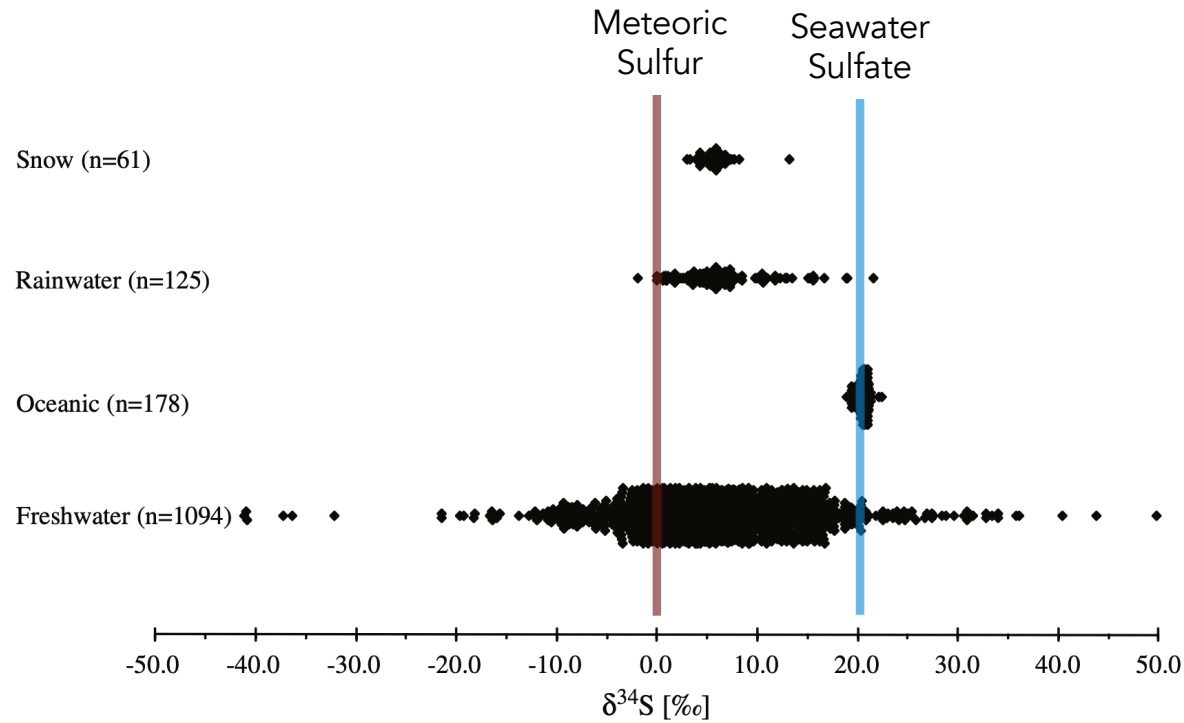
$^{34}\text{S}$ -depleted (low  $\delta^{34}\text{S}$ ) values a marker of **sulphate reduction** by bacteria  
(typically occurs in anoxic benthic habitats)

Sulphate is  $^{34}\text{S}$ -enriched

Sulphide is  $^{34}\text{S}$ -depleted



# Natural Range in $\delta^{34}\text{S}$



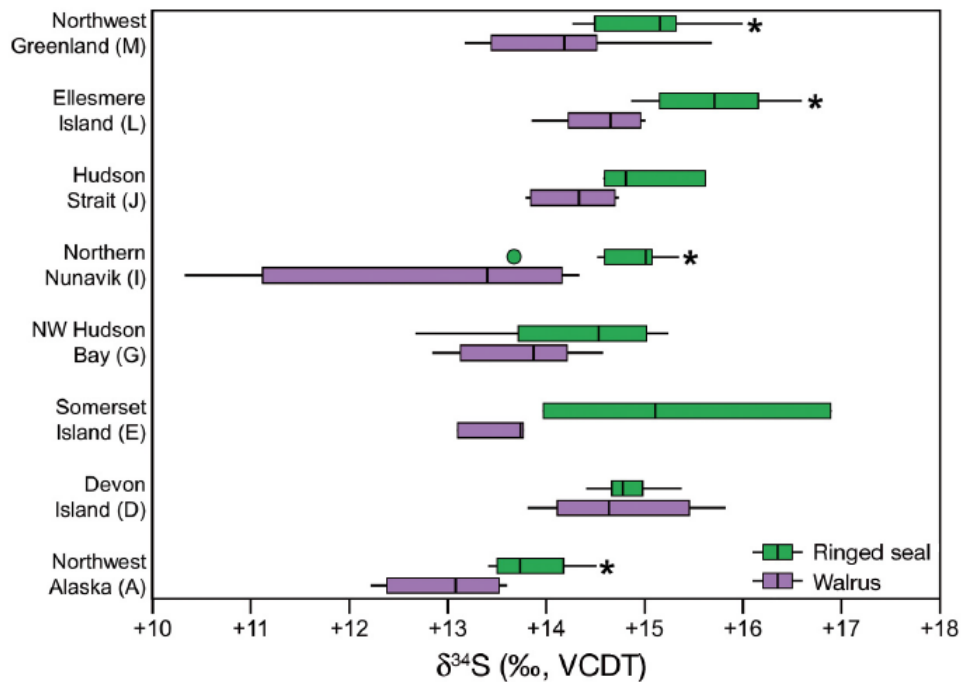
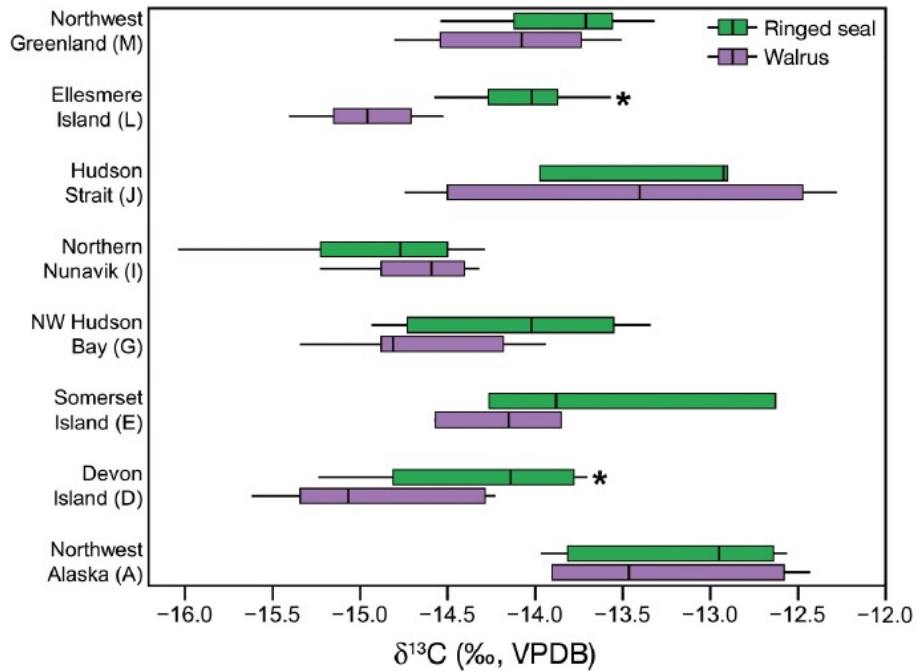
# Benthic versus Pelagic Foraging



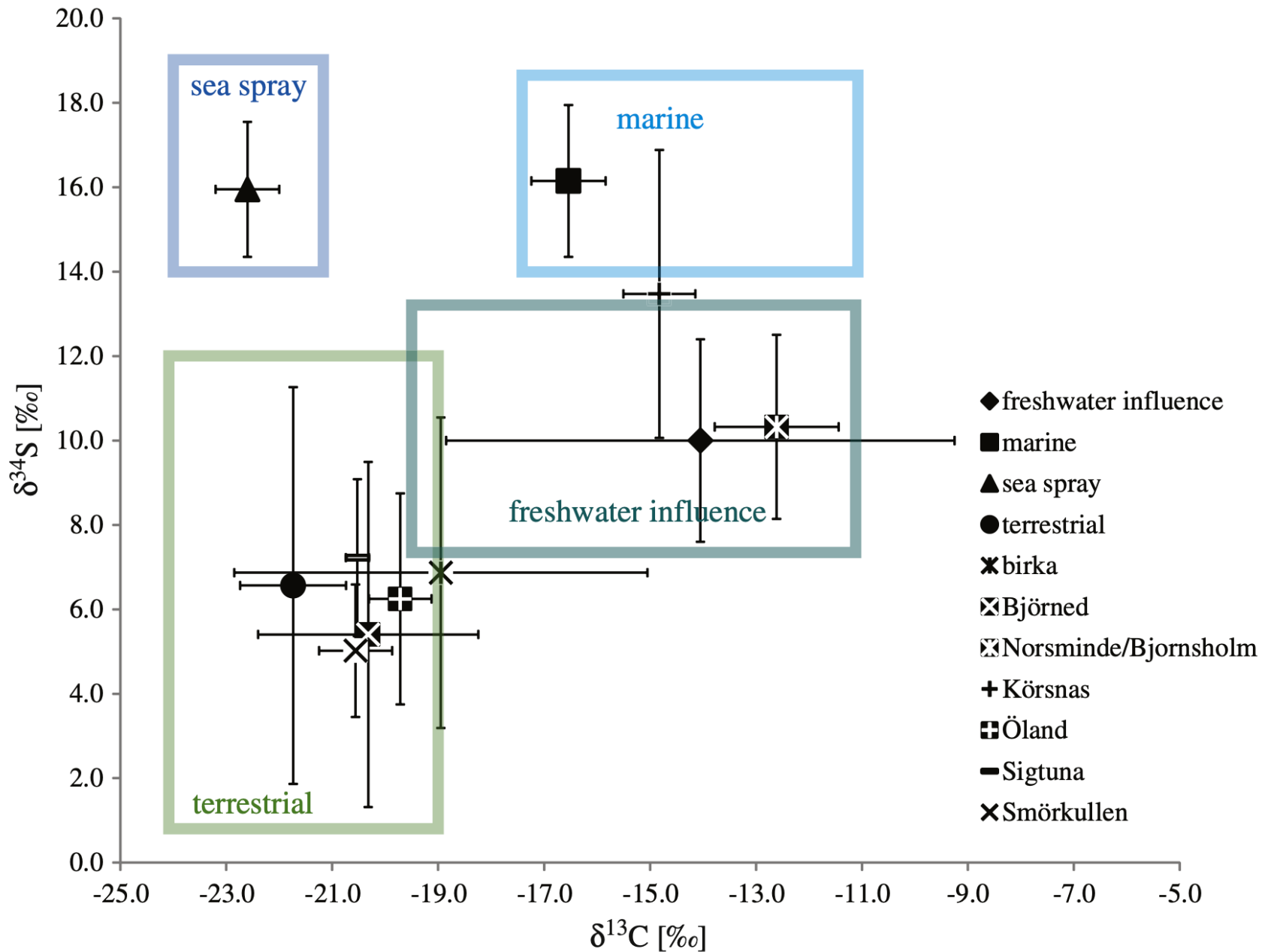
Benthic



Pelagic/Benthic



# Marine vs Freshwater vs Terrestrial Resource Use: Ancient Humans



# Trophic Discrimination in $\delta^{34}\text{S}$

location	Fauna (diet)			Human (consumer)			$\Delta^{34}\text{S}_{\text{consumer-diet}}$	Reference
	n	Average $\delta^{34}\text{S}$	SD	n	Average $\delta^{34}\text{S}$	SD		
Björned (Sweden)	4	5.7	9.5	24	5.5	3.4	-0.1	Andersson (2006)
Grotta del Romito (Italy)	5	13.6	1.2	8	11.9	1.2	-1.7	Craig et al. (2010)
Körsnas (Sweden)	14	10.8	4.1	4	13.5	2.2	2.7	Fornander et al. (2008)
Smörkullen (Sweden)	11	4.1	3.8	43	4.9	43.0	0.8	Lindberg (2009)
Birka (Sweden)	3	-1.8	1.6	20	5.2	2.6	7.0	Linderholm et al. (2008a, 2008b)
Sigtuna (Sweden)	4	5.1	2.5	20	7.2	2.5	2.2	Linderholm and Kjellström (2011)
Vinca-Belo Brdo (Serbia)	5	3.9	1.0	5	3.0	0.5	-1.0	Nehlich et al. (2010)
Neckarsulm (Germany)	5	2.4	1.1	41	4.9	1.0	2.5	Nehlich and Wahl (2011)
Nieder-Mörlen (Germany)	6	1.9	2.4	6	2.1	1.9	0.3	Nehlich et al. (2011a)
Jena (Germany)	11	8.8	3.0	12	10.6	1.4	1.8	Nehlich (2012–2013)
Ibiza (Spain)	70	14.7	1.2	120	12.6	2.8	-2.1	Nehlich et al. (2012)
Benzingerode (Germany)	3	2.5	1.7	12	4.4	2.8	1.9	Nehlich et al. (2014)
Derenburg (Germany)	7	0.3	1.4	31	0.5	1.6	0.2	Nehlich et al. (2014)
Großstorkwitz (Germany)	1	-0.8		5	1.4	1.9	2.2	Nehlich et al. (2014)
Halberstadt (Germany)	4	0.6	2.9	34	1.8	0.9	1.3	Nehlich et al. (2014)
Karsdorf (Germany)	10	5.4	2.1	15	3.7	1.6	-1.7	Nehlich et al. (2014)
Kölsa (Germany)	2	4.1	2.5	3	3.0	2.6	-1.0	Nehlich et al. (2014)
Westerhausen (Germany)	6	5.4	0.9	19	4.9	2.9	-0.5	Nehlich et al. (2014); Nehlich et al. (2007/2009)
Magdalenberg (Germany)	8	2.6	3.4	38	3.5	1.5	0.9	Oelze et al. (2012a)
Bil'shivtsi (Ukraine)	18	7.9	5.2	1	3.0		-4.9	Privat et al. (2007)
Chicha (Russia)	19	11.0	5.9	10	16.2	3.9	5.3	Privat et al. (2007)
Carding Mill Bay (Scotland)	1	19.2		2	19.8	0.1	0.6	Richards et al. (2001a)
Thebes (Greece)	11	12.8	2.2	11	13.7	0.7	1.0	Vika (2009)
						Mean $\Delta^{34}\text{S}$	0.8	
						SD	2.5	