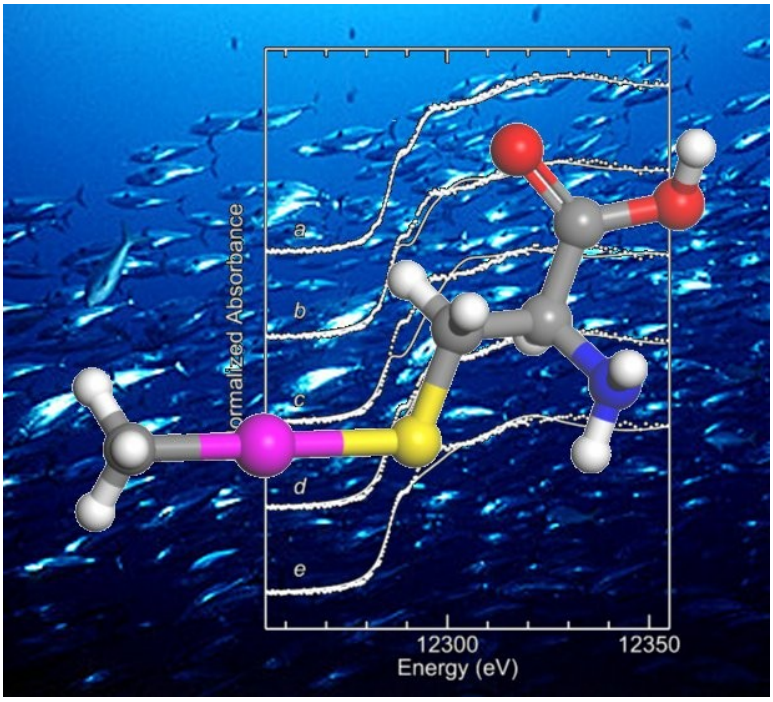
X-ray Absorption Spectroscopy Catches the Chemical Form of Mercury in Fish

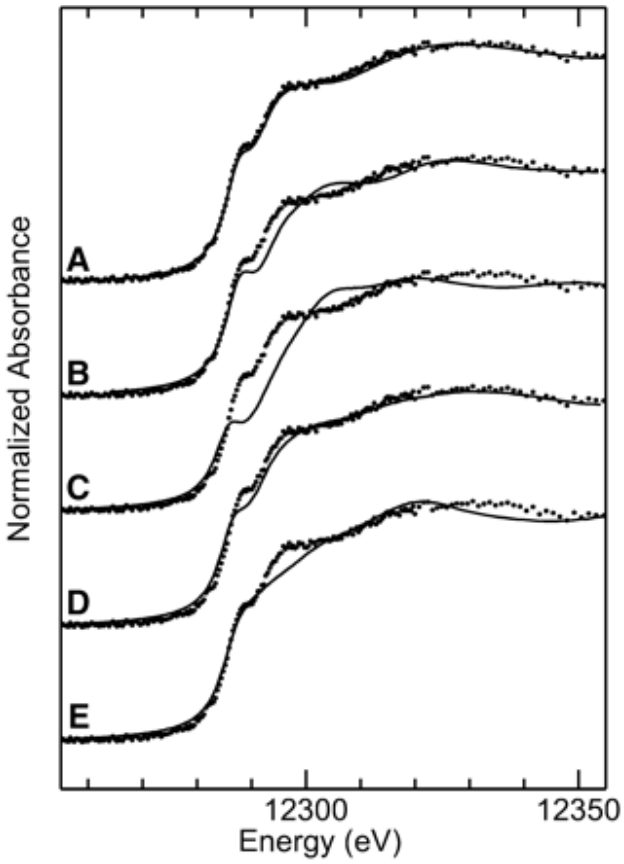


Mercury in the marine environment comes from both natural and anthropogenic sources, with the latter representing only a small component of the total. It impacts human health as the primary source of mercury (and especially neurotoxic methyl mercury compounds) in our diets, through consumption of fish and other seafood (1-4). Toxicological properties critically depend upon molecular form, but while fish are known to contain neurotoxic methylmercury compounds, the exact chemical nature of these was unknown. In an article in *Science*, Hugh Harris, Ingrid Pickering, and Graham George brought new insight to this long unanswered question when they reported that mercury in fish, specifically swordfish and orange roughy species is coordinated by carbon and sulfur and probably exists as methylmercury cysteine (5) in contrast to much of the prevailing thoughts.

Their identification of methylmercury cysteine as the most likely chemical form of mercury in fish resulted from a comparison of the Hg L_3 x-ray absorption spectra of mercury from the fish samples with those of twenty-six different standards (5). Notably, the spectra from the samples of the two fish species were indistinguishable indicating that they contain highly similar forms of mercury. Only spectra of methylmercury cysteine or closely related aliphatic thiols were consistent with those of the fish samples. In this family of compounds, methylmercury cysteine was considered to be the most likely match because of the substantial bioavailability of cysteine (5).

Many model studies of the toxicology of methylmercury in fish use methylmercury chloride to approximate the methylmercury compounds in fish. The findings of George and co-workers indicate that the methylmercury chloride may not be a good model of the mercury contained in fish. Furthermore, they point out that almost all toxicological and environmental literature contains an elementary chemical error. These works nearly always refer to the presence of CH_3Hg^+ species (also called the methylmercuric ion) which will not exist under physiological conditions. Thus, the mercury-chloride bond of methylmercury

chloride is quite covalent in aqueous solutions, with a bond distance of 2.30 Å (as determined from extended x-ray absorption fine structure data) and therefore this complex is not an accurate mimic of the thiol-bound form of mercury found in fish (5). The new understanding of the occurrence of methylmercury in fish as methylmercury cysteine therefore has important implications to the interpretation of previous toxicological studies. George and co-workers cite initial results from a model system in which zebrafish were shown to be capable of tolerating significantly higher levels of methylmercury cysteine than methylmercury chloride (5). Differences in the lipophilicity of these two compounds may indicate different membrane-crossing activities, and hence different toxicities. The authors are careful not to state whether mercury in fish should be considered more or less toxic as a result of their findings. Instead, they make the point that developing a molecular level understanding of mercury is essential to deciphering the biological activity of this toxin.



Concentrations of mercury as low as 400 nM were analyzed as part of this study. The detection of concentrations well below what had previously been possible was enabled by state-of-the-art detector technology combined with the high flux available at the SSRL structural molecular biology x-ray absorption spectroscopy beam line 9-3. The relevance of this technology to biological mercury speciation represents the advent of a new, ultra-sensitive probe for the study of molecular toxicology of heavy metals.

References

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