Accumulation of mercury in estuarine food webs: biogeochemical and ecological considerations.

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STATEMENTS AND DECLARATIONS

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The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government’s Office of the Gene Technology Regulator and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University. All research conducted for this thesis was approved by the University of Tasmania Animal Ethics Committee (Permit No. A0010843).

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Reproduced in chapter 2; is published in Marine Pollution Bulletin - Elsevier Publishing:


The candidate was the primary author who conceived the research idea, analysed the data and wrote the original manuscript (75 %); Catriona Macleod is the primary supervisor, providing advice on funding, framing the concept and manuscript preparation (10 %). Kerrie Swadling (10 %) provided statistical assistance and Sean Tracey (5 %) provided advice on manuscript preparation and fish biometrics. Data presented in this work was provided in part by Nyrstar Hobart, Tasmania, as part of the industry’s annual monitoring program.
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Paper 4, Spatial variability in selenium and mercury interactions in a key recreational fish species: implications for human health and monitoring.

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GENERAL ABSTRACT

Estuarine systems that are exposed to industrial pollutants often retain a high loading of contaminants, including mercury (Hg), due to prevailing physical, chemical and biological conditions. Estuarine biota are principally exposed to Hg through dietary uptake, which can lead to higher order species bioaccumulating significant concentrations that can also be harmful to human health if consumed. Methylmercury (MeHg) production, bioaccumulation, and biomagnification in estuarine food webs are broadly understood but our knowledge of Hg food pathways and selenium’s (Se) interaction with Hg is lacking. Current observations show poor correlation between bioaccumulation and environmental loadings, indicating that food web uptake and transfer of Hg are not straightforward. Understanding the mechanisms that underpin this variability is critical to quantifying and managing Hg exposure risks, and for developing appropriate management actions. The studies within this thesis examined the bioavailability, trophic magnification and bioaccumulation of Hg within a contaminated estuary to provide better capacity to manage the ecosystem and human health concerns.

Specifically this work focused on three areas: (1) The long-term capacity of resident fish to recover from Hg system contamination; (2) routes of Hg and Se trophic magnification within estuarine food webs; and (3) the influence of Se on Hg bioavailability and Hg toxicity. The study was based in the Derwent Estuary, Tasmania, a site of historical mercury pollution.

It was found that despite significant reduction of Hg discharges into an estuarine system, Hg concentrations in fish did not decrease, even after an extended period of time had passed (in this case, 37 years). The fact that Hg concentration in fish did not decline was only evident after application of biometric models, which suggests that monitoring of fish bioindicator species must include biological information to avoid misinterpretation of spatial and temporal trends of Hg contamination in biota.
Continuing, but spatially variable, methylation of Hg from sediments was found to be the key driver in the bioaccumulation of MeHg in resident fish. Co-contamination of Se and its close association with Hg in the sediments suggested a role of Se in reducing Hg bioavailability. Se uptake by resident fish was sufficient to maintain Se molar excess over Hg (a critical relationship in defining Hg toxicity), but an Se-based assessment of the risk of Hg toxicity to human consumers pointed to the potential for negative health effects associated with Hg in certain regions. This finding highlighted that, for human health assessments to be effective, the information on which they are based must be applied at a spatial scale appropriate to the source of Hg pollution.

To link an Hg source in the environment to fish, this research used a novel combination of Bayesian stable isotope mixing models and dietary analysis to provide refined trophic magnification models with which to evaluate Hg movement through food webs to the species of interest. The refined models reduced uncertainty in trophic magnification pathways and highlighted key benthic prey species as routes for Hg bioaccumulation.

These results provide a significant advance on the current understanding of Hg dynamics, specifically: improving our understanding of the relationship between Hg and Se; identifying issues with the way in which Hg concentrations fish are measured and reported so that the levels and risk can be more accurately understood; and identifying an improved approach for evaluating trophic interactions and bioaccumulation pathways. The findings will support estuarine management by informing existing monitoring programs and enabling better evaluation of the risks to human health in regions of Hg contamination.
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