Understanding the cascading effects of heavy metal contamination in Sydney estuary

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ABSTRACT

Ecosystem services associated with coastal systems are intrinsically interrelated meaning that an impact on one service will have cascading effects not only on other ecosystem services but also on the original ecosystem service affected. The ongoing failure of policies and interventions to provide long-term solutions to managing these coastal ecosystems (e.g. Jackson et al., 2001) has been referred to as policy resistance (Sterman, 2000) and provides much of the rationale for taking a more holistic 'systems' approach (Sterman, 2000). In this paper, we will present the 'work in progress' in exploring the efficacy of managing contamination of a heavily urbanised estuary (Sydney estuary, Australia). Specifically, we are interested in investigating the dynamic behaviours that characterise the problem of sediment contamination in the Sydney estuary and answering the question '*what is the implication of these dynamics for developing effective management interventions for Sydney estuary?*'

The systems assessment is following the first two stages of the five-step process outlined in Sterman (2000).

Stage 1 - Problem articulation

Sydney estuary (Figure 1) is located within a large city (Sydney, New South Wales, Australia) that has experienced strong transformation from an industrial-dominant to a residential-dominant landscape (Birch et al., 2015). A consequence of the 'industrial past' is the legacy industry-derived contaminant accumulations in the estuary sediment that persist to today (Birch, et al., 2015). Coupled with this is a landscape that is increasingly dominated by residential use (Figure 2), providing a mechanism for transporting catchment-derived contaminants via the stormwater system into the estuary (Figure 3) (Birch et al., 2015) and a governance system that is characterised by a "*complex web of management structures and interwoven ownership involved in its administration*" (Birch and Taylor, 2004).

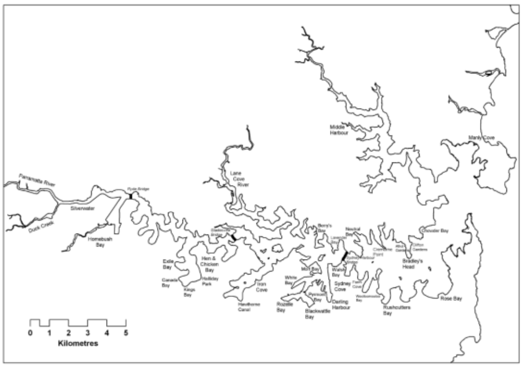

Figure 1. Sydney estuary, New South Wales, Australia

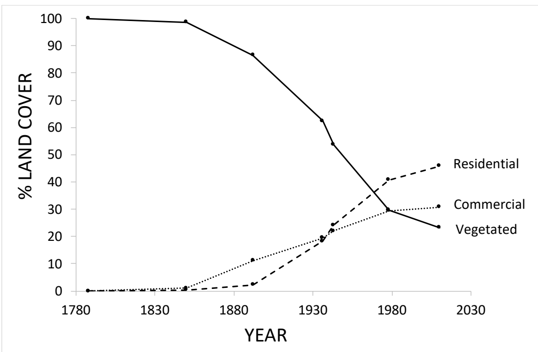

Figure 2. Land-use for Sydney from 1788 – 2010 (data from Birch et al., 2015)

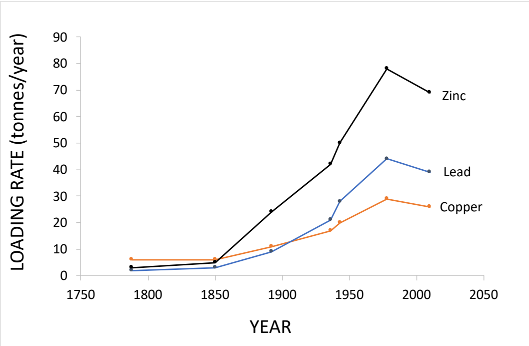

Figure 3. Historical stormwater loadings into Sydney Estuary of heavy metals (Birch et al., 2015)

Stage 2 - Dynamic Hypothesis

Currently, a causal loop diagram (CLD) is being constructed to reflect the dynamic hypothesis of why heavy metal contamination has occurred, and continues to occur in the estuary. A two-stage approach is used. Stage one is to develop a generic CLD that describes the system of environmental management. Stage two is to expand the generic CLD using a DPSIR (driver-pressure-state-impact-response) framework (Smeets and Weterings, 1999).

The generic CLD for this case is shown in Figure 4. This CLD captures the general pathways of risk awareness of the problem by the decision makers, represented by balancing loops B1 and B2 and the delay between the 'problem' occurring and 'management' becoming aware of this problem. This CLD also highlights two reinforcing loops (R2, R3) that represent how management reacts to 'public awareness' and how this in turn drives management action. Reinforcing loop R4 represents how the 'availability of resources' can generate a virtuous cycle or vicious cycle of management depending on the 'resources needed for other problems'.

Where to from here?

The next stage of this research is to apply the DPSIR framework for developing the CLD specifically for the problem. This process is currently under way and is based on a literature search (peer-reviewed and grey literature) to identify the 'driver', 'pressure', 'state', 'impact' and 'response' variables to be included in this revised CLD.

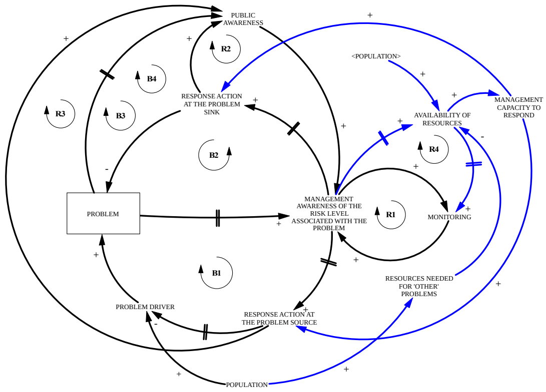

Figure 4. Contaminant inflow and management resulting from Stage 1 of the CLD development. Black connections represent the generalized problem and the blue lines indicate management response.

1. REFERENCES

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