22nd International Congress on Modelling and Simulation, Hobart, Tasmania, Australia, 3 to 8 December 2017
mssanz.org.au/modsim2017

EXTENDED ABSTRACT ONLY

Tackling the kraken – modelling cumulative risk in the oceans

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Abstract: The 21st century has seen a growing list of sectors expand into the ocean, with new industries added to the historical ones of fishing, transport and tourism. Activities once thought of as primarily terrestrial are growing in their marine footprint – energy generation, mining and infrastructure construction (floating platforms for ports and housing). In addition, seascapes are being influenced by modified water flows, run-off and pollutants. Things are further complicated by the non-stationary influence of climate drivers and the changing frequency of extreme events (which globally now cause billions of dollars of damage annually). This increasingly complex array of uses and stressors lays a growing burden and technical challenge at the feet of those tasked with understanding the risks and opportunities associated with the blue economy.

Low chance (but potentially high impact) events can no longer be ignored and this has led to demand for new risk assessment and modelling methods. To date foresighting is still the most widely used approach for complex risk assessment situations, as it is a rapid method that can cross scales and cope with vagary. While such exercises can be immensely insightful, particularly if they draw on a diversity of knowledge types that have a deep knowledge of the system, they tend to under-estimate variability, bifurcation points or the consequences of non-linear interactions of multiple variable types (whose alignment may see step changes in behaviour).

The next most commonly used marine risk tools are exposure, usage and vulnerability maps. Planners and other groups interested in marine and coastal issues find such maps an intuitive way of visualising the problem and potential solutions. Unfortunately, mapping currently struggles to move beyond additive layering of the pressures and system attributes. Uncertainty is also particularly difficult to incorporate comprehensively and consistently.

Presently tackling non-linearity and uncertainty in a consistent way has typically been achieved via a range of modelling tools, including: qualitative models that bring together diverse data sources and analyse the system using signed diagraphs and matrix algebra; Bayesian networks which can be used to explore probabilistic outcomes of perturbations and cascading effects; statistical approaches that use well understood relationships between variables to explore combined pressures, changing distributions or zones of influence; and process models applied across entire life cycles or socioecological systems. Common features of these tools are that they can (i) encompass multiple stressors, scales and their interconnections; and (ii) have the capacity to express multiple potential endpoints or system structures. Using a range of approaches also provides a means of handling model structural uncertainty, one of the key but often unacknowledged sources of uncertainty.

The value of all of these tools can be maximised by using a staged approach to match the complexity of the assessment method with the complexity of the question. A staged approach screens scope (temporal and spatial scales), the number, nature and connectedness of components and thereby identifies relevant methods and complexity. Many questions can be tackled straightforwardly using existing approaches - e.g. single risks with clear flow-on effects or even the accumulation of multiple low risk activities that cumulatively build risk to more worrying levels (Figure 1). Integrated models can be used to tackle more complicated situations where there are multiple interacting activities in one location or mixes of uses and stressors changing through time. These later approaches can be resource intensive exercises and rapid coherent alternative methods for assessing risks resulting from non-linear interactions of activities represent a gap in the toolbox. Addressing this hole represents a great opportunity for quantitatively skilled scientists to help society make sure the blue economy proves to be more sustainable and with less pitfalls than its terrestrial counterparts.

Keywords: *Cumulative impacts, risk*