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## Viewpoint

## The need for a formalised system of Quality Control for environmental policy-science

Piers Larcombe<sup>a,b,\*</sup>, Peter Ridd<sup>c</sup><sup>a</sup> RPS MetOcean Pty Ltd., 31 Bishop St., Jolimont 6014, Australia<sup>b</sup> School of Earth and Environment, The University of Western Australia (M004), 35 Stirling Highway, Crawley, WA 6009, Australia<sup>c</sup> Marine Geophysics Laboratory, College of Science and Engineering, James Cook University Townsville, 4811, Australia

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## ABSTRACT

Research science used to inform public policy decisions, herein defined as “Policy-Science”, is rarely subjected to rigorous checking, testing and replication. Studies of biomedical and other sciences indicate that a considerable fraction of published peer-reviewed scientific literature, perhaps half, has significant flaws. To demonstrate the potential failings of the present approaches to scientific Quality Control (QC), we describe examples of science associated with perceived threats to the Great Barrier Reef (GBR), Australia. There appears a serious risk of efforts to improve the health of the GBR being directed inefficiently and/or away from the more serious threats. We suggest the need for a new organisation to undertake quality reviews and audits of important scientific results that underpin government spending decisions on the environment. Logically, such a body could also examine policy science in other key areas where governments rely heavily upon scientific results, such as education, health and criminology.

## 1. Introduction

Since the early beginnings of Science in the time of the ancient Greeks, the scientific method has completely revolutionized human existence and almost always for the better. Science has progressed by constant checking, replication, argument and improvement. In some areas of science, such as Newton's Laws of Motion, checks are effectively done billions of times every day when people fly in a plane, drive a car or walk across a bridge. Newton's Laws of Motion are so well tested, checked and replicated that we stake our lives on them. But most science is not massively validated in this way and is thus not as reliable. Here we focus on the extent to which policy-science is checked, tested and replicated, and we define the term “policy-science” to mean all science used as the basis for making expensive or important decisions by governments to make and deliver their policies. Note that “policy-science” as defined here does not refer to the science of making good policy, but rather the science upon which particular policies are to be based. So, we join these words together for convenience only, and emphasise that good science is different and clearly distinct from policy-making processes and the resulting policy itself. The connections between science and policy are complex. Although science forms only one of the wide range of inputs to policy-making (e.g. Fig. 1), a policy is likely to be worse if the science is itself less than credible and

defensible. Scientists play the key role of ensuring that this input is objective and of the highest quality, so that policy-makers and politicians alike can be best informed of the scope and strength of the knowledge and also, importantly, of the key uncertainties (Rutter and Gold, 2015). Recent examination of policy proposals in the UK indicate that there is a deal of work left to do before it is clear exactly how Government policy has used science and evidence in policy formulation (Sense About Science, 2016).

Policy-science is also in a different category to the science which may ultimately be used by commercial companies for industrial applications, where it is up to the company to determine and test its reliability, because the company is taking the risk. Thus, the critical distinction between policy-science and the rest of science is the active use by government, often to make expensive and important decisions on behalf of the public. It is therefore vital to understand what measures governments take to make sure they are basing decisions on well tested, checked, replicated, sound science, and in our case, the environmental sciences.

One of the motivations for this work has been the revelations from other parts of the scientific literature that there may be major systemic failing in science Quality Assurance (Ioannidis, 2005, 2014). (To clarify the terminology, in quality management terms, the term Quality Control (QC) is used to verify the quality of the output, through inspection

\* Corresponding author at: RPS MetOcean Pty Ltd., 31 Bishop St., Jolimont 6014, Australia.  
E-mail address: [piers.larcombe@uwa.edu.au](mailto:piers.larcombe@uwa.edu.au) (P. Larcombe).



Fig. 1. A graphic illustrating 22 factors that can influence the decisions taken by UK government ministers (after Larcombe, 2007).

and testing, whereas Quality Assurance (QA) is the process of managing for quality. In the ISO 9000 standard (ISO, 2005), clause 3.2.10 defines Quality Control as: “A part of quality management focused on fulfilling quality requirements” and Clause 3.2.11 defines Quality Assurance as: “A part of quality management focused on providing confidence that quality requirements will be fulfilled”. Perhaps the most high-profile example of systemic failure comes from the biomedical sciences, where checks made on peer-reviewed science indicate that a large number of important papers are found to be wrong. Prinz et al. (2011) of the German drug company Bayer, writing in the journal ‘Nature Reviews Drug Discovery’ claimed that 75% of the literature used for potential drug discovery targets is unreliable. This issue has come to some international prominence:

“A rule of thumb among biotechnology venture-capitalists is that half of published research cannot be replicated. Even that may be optimistic. Last year researchers at one biotech firm, Amgen, found they could reproduce just six of 53 “landmark” studies in cancer research.”  
(The Economist, 19/10/2013)

Other authors have reported the frequency of irreproducibility at around 50% (Hartshorne and Schachner, 2012; Vasilevsky et al., 2013). It has also been suggested that false or exaggerated findings in the literature are partly responsible for up to 85% of research funding resources being wasted (Chalmers and Glasziou, 2009; Ioannidis, 2014; Macleod et al., 2014). Despite replication studies being fundamental to establishing science reliability, such studies are rarely funded, and are not generally seen as a way of advancing a scientific career (Ioannidis, 2014).

A concern over reproducibility is shared by some editors of major journals. Marcia Angell, a former editor of the New England Journal of Medicine, stated

“It is simply no longer possible to believe much of the clinical research that is published, or to rely on the judgment of trusted physicians or authoritative medical guidelines. I take no pleasure in this conclusion, which I reached slowly and reluctantly over my two decades as an editor of *The New England Journal of Medicine*.”  
(Angell, 2009)

The editor of *The Lancet* stated that

“The case against science is straightforward: much of the scientific literature, perhaps half, may simply be untrue. Afflicted by studies with small sample sizes, tiny effects, invalid exploratory analyses, and flagrant conflicts of interest, together with an obsession for pursuing fashionable trends of dubious importance, science has taken a turn towards darkness.”

(Horton, 2015)

The financial costs of irreproducible biomedical research are significant. Freedman et al. (2015) estimated that the cumulative prevalence of irreproducible preclinical research exceeds 50%, which in the United States alone, results in approximately US\$28 billion per annum spent on research that is not reproducible. Similar concerns about QC occur in other areas, and in particular psychology, where there is

“growing concern regarding the replicability of findings in psychology, including a mounting number of prominent findings that have failed to replicate via high-powered independent replication attempts.”

(LeBel, 2015)

In introducing a special edition on “Replicability in Psychological Science: A Crisis of Confidence”, the editors ask the question

“is there currently a crisis of confidence in psychological science reflecting an unprecedented level of doubt among practitioners about the reliability of research findings in the field?”

(Pashler and Wagenmakers, 2012; see also Wagenmakers et al., 2012)

and answer themselves in the affirmative, warning that

“Research findings that do not replicate are worse than fairy tales; with fairy tales the reader is at least aware that the work is fictional.”

Doubts about the validity of published literature have also spread to research in special education, where problems with replication are also evident. Cook (2014) specifically notes the problems in bio-medical science and psychology, and asked whether similar issues would be evident in educational research, concluding that

“To avoid leaving policy makers and practitioners between a rock (making decisions without empirical evidence) and a hard place (making

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