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Review

Reporting marine climate change impacts: Lessons from the science-policy interface

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ABSTRACT

Climate change science can trace its origins back to the early 19th Century although interest really took off in the 1980s, when public interest and research activity proliferated as the potential negative effects of global warming became clear. The impacts of climate change on the marine environment was receiving little attention at this time, but in recent years has started to "catch up" both in terms of research activity and public and policy interest. In the UK, the Marine Climate Change Impacts Partnership (MCCIP) has played a key role in transferring the emerging evidence base on marine climate change impacts to decision makers through the development of climate change report cards. Since publishing its first card back in 2006, the MCCIP cards have become established as the principal source of marine climate change impacts evidence for policy makers in the UK, and similar approaches have been adopted elsewhere. Here we broadly describe how the climate change evidence base has evolved over time, with a focus on the marine evidence base, and the approach adopted in the UK by MCCIP to rapidly transfer this evidence to end users. The SIIRMS model developed by MCCIP to ensure integrity and independence in the scientific translation process is explored, along with wider lessons learnt along the way (e.g. about communicating uncertainty) and the impact MCCIP has had on informing decision making.

1. Climate change science: a brief history

The first 150 years of climate change science was characterised by occasional but important reports and observations leading to a gradual development of knowledge over time. The earliest climate observation is often reported as that by the French physicist Joseph Fourier who demonstrated that the Earth would be colder if it lacked an atmosphere (Fourier, 1824). In 1859 John Tyndall first described the 'greenhouse effect' whereby changes in the concentration of gases in the atmosphere could lead to changes in climatic conditions (Tyndall, 1859) and in 1896 the Swedish chemist Svante Arrhenius used estimates of coal burning to calculate that emissions from human industry might someday cause a warming of the atmosphere (Arrhenius, 1896). Research linking CO_2 production to global temperatures continued in the 20th century (e.g. Revelle and Suess, 1956; Callendar, 1938) although it is interesting to note that scientists from Arrhenius through to Guy Callendar did not necessarily see an increase in global temperatures as a negative phenomenon and in fact tended to draw out positive benefits if anything (Bowen, 2006). From 1975 when the term "global warming" was coined by the US scientist Wallace Broecker (Broecker, 1975), the focus was shifting to the negative impacts of anthropogenically-induced climate change. This concern began to spread within and beyond the scientific community, with public perception of climate change as a problem increasing rapidly throughout the 1980′s and 1990′s (Capstick et al., 2015).

1.1. The challenge: a rapidly expanding evidence base

The need to collate and assess the rapidly growing body of evidence on climate change led to the formation of the Intergovernmental Panel on Climate Change (IPCC) in 1988 and since then the amount of research carried out into climate change has increased dramatically across countries and scientific disciplines (Haunschild et al., 2016; Jinfeng et al., 2011). The amount of specifically marine focused climate research has also increased dramatically although reporting marine environmental impacts was not initially given as high a priority as

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terrestrial studies: only 2 pages of the 414 page first IPCC report focused on impacts on marine ecosystems, and as recently as the 2007 IPCC 4th Assessment Report, 28,586 significant biological changes in terrestrial systems were highlighted, but only 85 were from marine and freshwater systems (Richardson and Poloczanska, 2008), a deficiency addressed by the establishment of an international symposium on the effects of climate change on the world's oceans (Barange et al., 2016). By the time the fifth assessment report was published during 2013 and 2014 (IPCC, 2014; IPCC 2013), it was clear efforts were being made to address these deficiencies in reporting on marine climate change, with dedicated chapters on oceans and marine and coastal ecosystem responses. A dedicated IPCC special report on oceans and cryosphere's is planned before the Sixth Assessment Report is published. Reporting on marine climate change impacts is therefore finally starting to 'catch up' with the proliferation of marine climate change research since the first IPCC report was published, given the number of papers on marine climate science has doubled every year since 1990 (Jex, 2016).

2. A new model for evidence transfer: the marine climate change impacts partnership

For the UK, a significant event in marine climate reporting was the publication of a major government report into the State of UK Seas (Defra, 2005). This report included an examination of the impacts of climate change but the information was disparate and far from comprehensive. The Marine Climate Change Impacts Partnership (MCCIP) was initiated as a direct response to recommendations in the report, to act as a 'neutral clearing house for marine climate change evidence relevant to the UK' (see Page 4, Defra, 2005). The MCCIP partnership necessarily includes participants working along the spectrum from pure science to policy and many individuals on its working groups, as well as contributing authors, have considerable experience operating in both science and policy contexts. Since 2006 MCCIP has reported on the physical drivers of marine climate change; and their impacts on marine biodiversity; cleanliness and safety; and commercial productivity of the coastal and marine environment around the UK (MCCIP 2017, 2015, 2013, 2012, 2010, 2009, 2008, 2006) with the aim to "transfer high quality evidence on marine climate change impacts, and guidance on adaptation and related advice, to policy advisors and decision-makers" (MCCIP, 2014). In doing so, MCCIP provides an independent translation of information from the scientific to the political and public arena, which is vital if policy and action related to climate change impacts is to be evidence-based, or at least 'evidence informed' (Kennel et al., 2016; Rose, 2014; Urwin and Jordan, 2008). The need for a mechanism for transferring this evidence to policy-makers led to the development by MCCIP of the world's first marine climate impacts report card. The MCCIP report card model has since been adapted for use in Australia (Poloczanska et al., 2012, 2009) and the Caribbean (CMEP, 2017) as well as for terrestrial and freshwater climate reporting in the UK (Morison and Matthews, 2016; Watts and Anderson, 2016; Kovats, 2015; Morecroft and Speakman, 2015) leading to them now being recognised as an important medium for communicating climate science in a way that can bridge the science policy interface (Fung et al., 2015). The more than 10 years' experience MCCIP has in working at the science-policy interface to report on marine climate change impacts, and the fact that the model is being more widely adopted, means an examination of the effectiveness of the MCCIP model of reporting is particularly apposite. Specific lessons learned on the effectiveness of the MCCIP model for use at the science-policy interface are therefore discussed with a focus on the issue of reporting uncertainty and on ensuring independence and integrity. The results of this review are used to draw some general conclusions and make recommendations for those working at the interface between science and policy.

2.1. The MCCIP process

Before looking at the lessons learned it is useful to note the process by which MCCIP produces its report cards − further information is then provided in Section 2.3.1. The MCCIP Report Card Working Group sets out proposals to the MCCIP Steering Group about the delivery of any report card, including information on timing and the subject matter to be covered. Once agreed by the steering group, the work group commissions lead authors to provide the underlying evidence for the report card (the number of lead authors invited depends on the number of topics being covered). Lead authors are provided with a template with specific terms of reference asking them to take responsibility to invite co-authors in their area so the submission reflects the view of experts in their field. Peer reviewers are also identified at an early stage by the working group. Once submissions have been submitted, peer-reviewed and finalised, the working group collates the evidence (based on the work group Terms of Reference and refines the key messages for the target audience (the final form of the key messages are agreed in liaison with the lead authors).

3. Lessons from the science-policy interface

The 'science-policy interface' is a simple and widely-used way of referring to the intersection between the worlds of science and policy, the assumption being that they operate in separate but overlapping spheres. The term can also refer to specific processes as in Van den Hove's definition of science–policy interfaces as social processes which encompass relations between scientists and other actors in the policy process (Van den Hove, 2007). There is a history of academic research into methods to improve the science-policy interface including climate science and policy specifically (Howarth and Painter, 2016; Jones et al., 1999) but for many scientists it is only experience of this interface that provides the insight required to identify and address the numerous challenges (Watson, 2005). MCCIP is no exception and the focus here is on what has been learned in terms of communicating uncertainty and maintaining scientific integrity and independence. There is an additional challenge in that scientific information needs to be conveyed in a way that is easy for the 'layman' to understand; a problem exacerbated by the fact that the audience for the information can range widely in expertise from those with scientific training to those with very little or no experience of interpreting and dealing with scientific outputs and knowledge, as well as wide differences in values and perspective (Grorud-Colverta et al., 2010; Nisbet and Scheufele, 2009). The translation, provision and interpretation of scientific information for a non-specialist audience i.e. making sure that technical information is conveyed in a way that makes it accessible to non-specialists, has however been dealt with in detail elsewhere (Brownell et al., 2016; Moser, 2016).

4. Lessons from the science-policy interface: dealing with uncertainty

Scientific information can be complex and one of the most challenging aspects of communicating complexity is working with, and conveying, the concept of uncertainty (Wardekker et al., 2008). Policy-makers and managers may want to use the evidence supplied to make decisions, take action and even develop or amend legislation (Frost et al., 2016), which is why it is vital that some indication of uncertainty is provided with scientific information. A well-established mechanism for communicating uncertainty is the use of a 'confidence rating' (e.g. Laffoley and Baxter, 2016; UKMMAS, 2010). The confidence rating adopted by MCCIP draws on the IPCC approach in addressing uncertainty by reflecting both the consensus (degree of agreement amongst the scientific community) and the amount of scientific data available on which findings are based (Mastrandrea et al., 2010). The MCCIP report cards display two confidence ratings for each topic, one