attention to the quality of predictions[9]. Recommending that predictions should where possible be accompanied by attribution studies would encourage researchers to confront the difficulty of attribution. Identifying processes and modelling them with sufficient power to detect the signal of anthropogenic climate change in observations of natural systems should be the goal, and would provide the basis for estimates of confidence in predictions. Predictive models of biological systems should be capable of reproducing observed changes with a reasonable level of skill. Failure to do so undermines their credibility, particularly where past variations in environmental drivers, such as temperature or vertical ocean mixing, are comparable in magnitude to expected future changes due to anthropogenic climate change.

Finally, the authors' proposition that biologists are now expected to change their research focus in response to contrarian arguments might be taken seriously if such arguments had scientifically tractable content. The guidance paper by the Intergovernmental Panel on Climate Change[10] cited by the authors contains no recommendation concerning the need for more attribution studies or what form they should take — a remarkable omission if the panel is indeed trying to set an agenda. ❐

References

1. Parmesan, C., Duarte, C., Poloczanska, E., Richardson, A. J. & Singer, M. C. *Nature Clim. Change* **1,** 2–4 (2011).
2. Donner, S. D. *et al. Proc. Natl Acad. Sci. USA* **104,** 5483–5488 (2007).
3. Kearney, M. R. *et al. Biol. Lett.* **6,** 674–677 (2010).
4. Spence, A., Poortinga, W., Butler, C. & Pidgeon, N. F. *Nature Clim. Change* **1,** 46–49 (2011).
5. Schiermeier, Q. *Nature* **470,** 316 (2011).
6. Brander, K. *Mar. Pollut. Bull.* **56,** 1957–1958 (2008).
7. Black, R. Coral reefs heading for fishing and climate crisis. *BBC News Online* (23 February 2011); available via http://go.nature.com/uKnYFQ.
8. Stock, C. *et al. Prog. Oceanogr.* **88,** 1–27 (2011).
9. Planque B. *et al. ICES J. Mar. Sci.* doi:10.1093/icesjms/fsr007 (2011).
10. Hegerl, G. C. *et al.* in *Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution Related to Anthropogenic Climate Change* (eds Stocker, T. F. *et al.*) (IPCC Working Group I Technical Support Unit, 2010).

Acknowledgements

This response developed from discussions with members of the Marine Climate Impacts Working Group at the National Center for Ecological Analysis and Synthesis.

Keith Brander[1,2*], John Bruno[3], Alistair Hobday[2] and David Schoeman[4,5]

[1]DTU Aqua, Technical University of Denmark, Charlottenlund Slot, DK-2920 Charlottenlund, Denmark, [2]Climate Adaptation Flagship, CSIRO, GPO Box 1538, Hobart, Tasmania 7001, Australia, [3]Department of Biology, University of North Carolina, Chapel Hill, North Carolina 27599-3280, USA, [4]Environmental Sciences Research Institute, University of Ulster, Coleraine BT52 1SA, Northern Ireland, [5]Zoology Department, PO Box 77000, Nelson Mandela Metropolitan University, Port Elizabeth 6031, South Africa.

*e-mail: kbr@aqua.dtu.dk

CORRESPONDENCE:

Tried and tested

To the Editor — Parmesan and colleagues[1] claim that the Intergovernmental Panel on Climate Change (IPCC) "advocates an ever-more-detailed approach to attribution" in a guidance paper for its fifth assessment report, and that applying this approach to biological systems "effectively yields to the contrarians' inexhaustible demands for more 'proof' [of human-induced climate change], rather than advancing the most pressing and practical scientific questions." Although we welcome the scientific debate on this issue, we provide some background to this topic from the IPCC Working Group I to address these assertions.

The question of whether an observed change is caused by human activities is among the most often asked by the public, and is of immediate relevance to policymakers: planning for the future requires consideration of the climate forcing due to human-induced factors and the impacts associated with it. Therefore, scientists are called on to investigate this issue with all the tools available.

Detection and attribution — enabling the quantitative distinction between anthropogenic climate change and natural climate variability — has become a robust and well-tested methodology in climate science with a growing body of relevant peer-reviewed literature[2]. Some major statements in the Working Group I contributions to the third and the fourth assessment reports of the IPCC were based on it, and it will also be emphasized in the IPCC's fifth assessment report in both Working Groups I and II, with Working Group I devoting an entire chapter to detection and attribution at global to regional scales.

To support the scientific community engaged in the assessment process, IPCC Working Groups I and II jointly held an IPCC expert meeting on 'Detection and Attribution Related to Anthropogenic Climate Change' in September 2009. The meeting goal was to develop consistency and coherence of terminology used in detection and attribution studies, in particular where they extend to impact-relevant climate change, for example, detection and attribution of extreme events or changes in the carbon cycle and in ecosystems.

The product of this meeting was a 'Good Practice Guidance Paper'[3], summarizing the discussions and clarifying methods, definitions and terminology across the IPCC Working Groups. It is a carefully formulated document, jointly authored by scientists from the physical sciences and from the impacts and ecosystem research communities, and in no way makes recommendations on research needs. It is fully in line with the mandate of the IPCC, which is to comprehensively assess the available science while not performing or promoting specific science. ❐

References

1. Parmesan, C., Duarte, C., Poloczanska, E., Richardson, A. J. & Singer, M. C. *Nature Clim. Change* **1,** 2–4 (2011).
2. Stone, D. A. *et al. Annu. Rev. Env. Resour.* **34,** 1–16 (2009).
3. Hegerl, G. C. *et al.* in *Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution Related to Anthropogenic Climate Change* (eds Stocker, T. F. *et al.*) (IPCC Working Group I Technical Support Unit, 2010).

Thomas F. Stocker[1,2*], Qin Dahe[1,3], Gian-Kasper Plattner[2], Pauline Midgley[2] and Melinda Tignor[2]

[1]Co-Chairs Working Group I, Intergovernmental Panel on Climate Change, [2]Intergovernmental Panel on Climate Change Working Group I Technical Support Unit, University of Bern, Zähringerstr. 25, 3012 Bern, Switzerland, [3]China Meteorological Administration, No. 46 Zhongguancun Nandajie, Beijing 100081, China.

*e-mail: stocker@ipcc.unibe.ch

CORRESPONDENCE:

Difficult but not impossible

To the Editor — Parmesan and colleagues[1] criticize a guidance paper that was produced following an Intergovernmental Panel on Climate Change (IPCC) expert meeting on detection and attribution[2]. This paper includes methods that seek to establish links between observed changes and external drivers of climate change, including greenhouse gases. Parmesan and co-authors argue that attempting to attribute ecological impacts to rising greenhouse gases is 'misguided' and instead propose concentrating on assessing the interacting roles of climate and other environmental factors, regardless of their underlying causes.

The guidance paper — of which most of us are co-authors — does not advocate one particular type of research over another. Rather, it attempts to bring clarity and uniformity to the diverse set of methods associated with the detection and attribution of climate change and its impacts. We contend, however, that detection and attribution is both possible and advisable.

We agree that it is important to carefully account for confounding drivers of change, and this is indeed stressed in the guidance paper. It seems near-sighted, however, to suggest that the difficulty of attributing a species' extinction to the human influence on climate makes any such attempt 'misguided' in principle. Parmesan and co-authors observe that it is difficult to attribute the extinction of a species known to have been caused by a single event to human-induced climate change with high confidence. It is incorrect, however, to suggest that this means it is 'inappropriate' even to try. If human influence on climate doubles or quadruples the probability of a given event occurring — as has been estimated in a few well-studied cases — then there is a clear sense in which its causal role can be quantified, albeit probabilistically[3].

Attributing events to natural versus anthropogenic causes may not always be the most important research goal, particularly in the case of some conservation challenges. However, being able to identify changes that are due to greenhouse-gas forcing has important implications for what lies ahead. A change associated with greenhouse-gas forcing is likely to continue, while changes due to internal climate variability may be more likely to reverse. Quantifying the impacts of anthropogenic climate change in this way is also important in guiding the allocation of resources available for adaptation. ❐

References
1. Parmesan, C., Duarte, C., Poloczanska, E., Richardson, A. J. & Singer, M. C. *Nature Clim. Change* **1,** 2–4 (2011).
2. Hegerl, G. C. *et al.* in *Intergovernmental Panel on Climate Change Expert Meeting on Detection and Attribution Related to Anthropogenic Climate Change* (eds Stocker, T. F. *et al.*) (IPCC Working Group I Technical Support Unit, 2010).
3. Stott, P., Stone, D. & Allen, M. *Nature* **432,** 610–614 (2004).

Ove Hoegh-Guldberg[1]*, Gabi Hegerl[2], Terry Root[3], Francis Zwiers[4], Peter Stott[5], David Pierce[6] and Myles Allen[7].
[1]Global Change Institute, University of Queensland, St Lucia, Queensland 4072, Australia, [2]Grant Institute, The King's Buildings, West Mains Road, University of Edinburgh, Edinburgh EH9 3JW, UK, [3]Woods Institute for the Environment, Stanford University, 473 Via Ortega, Stanford, California 94305, USA, [4]University of Victoria, PO Box 1700 Sta CSC, Victoria, British Colombia V8W 2Y2, Canada, [5]Met Office Hadley Centre, FitzRoy Road, Exeter EX1 3PB, UK, [6]Climate Research Division, Mail Stop 0224, Scripps Institution of Oceanography, La Jolla, California 92092-0224, USA, [7]School of Geography and the Environment, University of Oxford, Oxford OX1 3QY, UK.
*e-mail: oveh@uq.edu.au

CORRESPONDENCE:

The current status of climate change research

To the Editor — A deeper understanding of current climate change and the mitigation of its potential future effects are among the greatest challenges facing modern science and society as a whole. In recognition of this, the past few years have seen a striking growth in funding and publication of climate change research, a trend that looks set to continue. Moreover, these trends have been matched by an increase in media coverage of climate change. Here we provide an overview of these trends.

US government and philanthropic foundation funding specifically for climate change research has increased to about $3.5 billion per year[1,2], although numerous studies on the impacts of climate change are funded by other sources, see for example, ref. 3. The number of journals dedicated primarily or exclusively to climate change research doubled from 10 in 2006 to 20 in 2010, and at least two new titles have already been released this year (Fig. 1; Supplementary Table S1). This striking growth reflects an increasing interest and investment in this field by the major scientific publishers.

We queried the Web of Science (WoS) database to selectively identify climate change publications (Supplementary Table S2) and retrieved a total of 110,139 records. Exponential growth is clearly evident over the past 19 years (Fig. 1). Our data indicate that the number of publications per year doubled from 1997 to 2004, and from 2005 to 2009. In fact, almost half of the 110,139 retrieved records were published between 2006 and 2009.