



**nature**

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# climate change

## Refuges for marine biodiversity

**WORKING WITH NATURE**  
Ecosystem-based adaptation

**CARBON PRICING**  
Australia's great experiment

**PEAK TEMPERATURE**  
Equivalence of greenhouse-gas emissions





**COVER IMAGE**

Satellite images of sea surface temperature, such as the one illustrated on the cover, combined with global climate models provide evidence of a few key equatorial islands and atolls that may be spared the brunt of predicted tropical ocean warming and productivity decline. These islands may provide crucial refuges for marine biodiversity amid global climate change.  
Letter p530

COVER IMAGE: KRISTOPHER KARNAUSKAS

COVER DESIGN: KAREN MOORE

**ON THE COVER**

**Working with nature**  
Ecosystem-based adaptation  
Perspective p504

**Carbon pricing**  
Australia's great experiment  
Commentaries p475 and p477

**Peak temperature**  
Equivalence of greenhouse-gas emissions  
Letter p535



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**EDITORIAL**

469 **Australia sets price on carbon**

**OPINION & COMMENT**

470 **Correspondence: A critical role for carbon offsets**

471 **Commentary: Bridging the greenhouse-gas emissions gap**  
Kornelis Blok, Niklas Höhne, Kees van der Leun and Nicholas Harrison

475 **Commentary: Australia's carbon price**  
Frank Jotzo

477 **Commentary: Science and the governance of Australia's climate regime**  
Rodney J. Keenan, Lisa Caripis, Anita Foerster, Lee Godden and Jacqueline Peel

**FEATURE**

479 **Snapshot: Arctic ice turns to the dark side**  
Nicola Jones

**BOOKS & ARTS**

480 **Exhibition: Cultural response to climate change**  
Reviewed by Elizabeth Straughan and Deborah Dixon

480 **On our bookshelf**

**INTERVIEW**

482 **Underwater aquarium**  
Interview with Peter Brewer

**ANALYSIS**

484 **Market Watch: When carbon footprints hop**  
Anna Petherick

**RESEARCH HIGHLIGHTS**

486 **Our choice from the recent literature**

**NEWS & VIEWS**

488 **Energy policy: The fair cost of renewable energy**  
Michael Jakob

489 **Oceanography: Plankton in an acidified ocean**  
Allen J. Milligan

**PERSPECTIVE**

491 **A decade of weather extremes**  
Dim Coumou and Stefan Rahmstorf

497 **Biodiversity co-benefits of policies to reduce forest-carbon emissions**  
Jacob Phelps, Edward L. Webb and William M. Adams

504 **Harnessing nature to help people adapt to climate change**  
Holly P. Jones, David G. Hole and Erika S. Zavaleta



### Experimenting with the ocean

Late in 2011 California's Monterey Bay Aquarium Research Institute conducted the first controlled biological experiment on deep-sea animals using a Free-Ocean Carbon Dioxide Enrichment experiment — an experimental set-up that should have a number of benefits over conventional aquarium-based experiments. In an Interview, ocean chemist Peter Brewer talks to *Nature Climate Change* about the project, some initial findings and the prospects of this approach for the future.

[Interview p482]



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### Bridging the gap

In November 2011 the United Nations Environment Programme published a report called *Bridging the Emissions Gap*, which showed that for 2020 there is an emissions gap of approximately 12 gigatonnes of carbon dioxide equivalent between business-as-usual development and pathways compatible with a maximum temperature rise of 2 °C above pre-industrial levels. In a Commentary, Kornelis Blok and co-workers propose 21 initiatives (or wedges) — additional to those agreed at the United Nations climate conference in Copenhagen in 2009 — that could together stimulate sufficient reductions by 2020 to bridge the greenhouse-gas emissions gap.

[Commentary p471]

### Australian carbon policy

In this issue there are two Commentaries on Australian carbon policies. In the first, Frank Jotzo discusses Australia's recently adopted Carbon Pricing Mechanism. He argues that the policy's innovative design in price management and revenue recycling

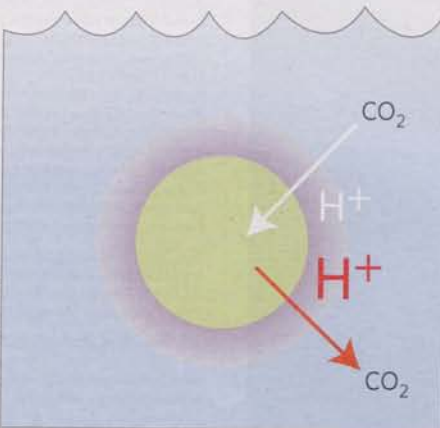
shows great promise, but nevertheless cautions that the scheme is vulnerable to the prevailing partisan politics in Australia. The second by Rodney Keenan and co-authors also focuses on the Carbon Pricing Mechanism and the extent to which scientifically sound information and advice have been used to support the policy's formulation. Overall Keenan and co-authors find that this approach gives hope that the country's climate change mitigation efforts can make an effective contribution to international objectives.

[Commentaries p475 and p477]

### Plankton experiences

Ocean pH is expected to drop by 0.3 units by 2100, but it remains unclear how plankton might respond. Now research shows that pH and carbonate chemistry at the exterior surface of marine organisms deviate increasingly from those of bulk sea water as organism metabolic activity and size increases. These deviations are expected to increase in the future as the buffering capacity of sea water decreases with decreased pH, and as metabolic activity increases with raised seawater temperatures, such that many marine plankton will experience pH conditions completely outside their recent historical range. Understanding of such deviations is important for predicting ecological response of different plankton.

[Letter p510; News & Views p489]



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### A creative cycle

The exchange of carbon between organisms and the environment is the inspiration for *Carbon 12*, an exhibition by five teams of artists and scientists that opened in Paris on 4 May and runs until 16 September this year. Under the aegis of Cape Farewell, each team has produced a creative response to climate change, with an emphasis on the

impact of the anthropogenically enhanced greenhouse effect on the carbon cycle. Elizabeth Straughan and Deborah Dixon review the exhibits.

[Books & Arts p480]



© RAPHAEL SEGUIN

### Outsourcing emissions

Despite having set, and even apparently met, legally binding commitments to reduce carbon emissions, many countries have increased their appetite for carbon-intensive consumer products, making up the difference through international trade. Essentially, this means that a significant proportion of carbon emissions have not been reduced but simply moved; pollution has been outsourced. Of course such pollution transfer is questionable at the best of times, but where the pollutant's effects are global in extent, the whole purpose of emissions reductions is undermined. Anna Petherick reports on the tricky task of regulating these elusive carbon flows.

[Market Watch p484]

### From the bottom up

The 2010 Cancún Agreement established a financial mechanism, through the Green Climate Fund, to support developing countries in greenhouse-gas emissions abatement. However, the different countries' financial needs are often assessed on the basis of top-down cost estimates of energy technologies. Now a study provides a more fine-grained bottom-up approach that highlights the need for a 'fair' baseline calculation methodology and calls for a phase-out of fuel subsidies.

[Article p548; News & Views p488]



# Cultural response to climate change

## EXHIBITION

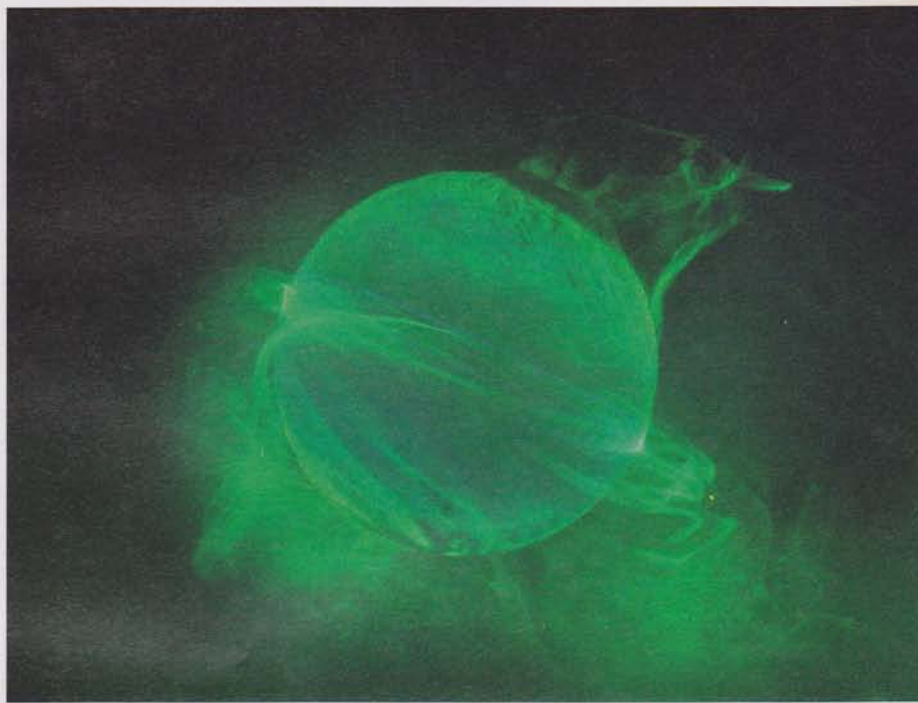
The continuous process by which carbon is exchanged between organisms and the environment is the inspiration for *Carbon 12*, an exhibition by five teams of artists and scientists. Under the aegis of Cape Farewell, a not-for-profit arts organization, each team has produced a creative response

to climate change, with a collective emphasis on the impact of the greenhouse effect on the carbon cycle.

But *Carbon 12* also refers to the cycle of thermonuclear reactions wherein isotopes of nitrogen and oxygen, as well as carbon, are produced. And, it is this reference that illuminates Cape Farewell's collaborative relationship with Électricité de France, a nuclear energy company, which provides the exhibition space. Current and future energy use will, of course, play a crucial role in climate change, and *Carbon 12* emphasizes by dint of contrast the relative 'cleanness' of fission and nuclear energy over and against burning and fossil fuels.

Cape Farewell has, since its inception in 2001, argued persuasively for the need for scientists to not only acknowledge the value of the arts as a means of shaping people's views on climate change, but to work collaboratively with artists, such that new forms of knowledge and practice can emerge. This collaborative spirit is much in evidence in the curation as well as the content of *Carbon 12*. During the opening press conference, artists and scientists stood side by side to comment and reflect on the exhibits. The broader importance of the arts and humanities in helping to convey climate change and the scientific study thereof to a general public was acknowledged by the contemporaneous hosting of a wide-ranging debate at the Paris headquarters of the United Nations Educational, Scientific and Cultural Organization.

As a collection, the exhibits emphasize the sensuality of engaging with the elements of earth, water and air. This lends them a seductive quality that undercuts the conveyance of a cautionary warning concerning the detrimental impact of human activity. *Domestic Disaster 3: Planet Earth* (2012), for example, produced by artists Heiko and Helen Hansen (HeHe) in concert with Jean-Marc Chomaz (LadHyX



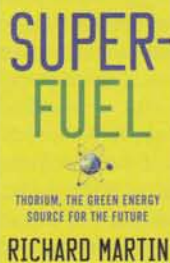
*Domestic Disaster 3: Planet Earth*, artwork by HeHe (2012). A collaboration with Jean-Marc Chomaz, assisted by Antoine Garcia, Hydrodynamics Laboratory, LadHyX, Ecole Polytechnique, Paris, France. Photo by Raphaël Seguin.

Laboratory, France), proffers a complex emotional response to air pollution. In a small dark space a globe sits in a tank of water as opera music plays in the background. The globe spins continuously on its axis and a light pointing towards the Northern Hemisphere flashes on, initiating the appearance of a vibrant green gas over the Arctic Circle. As the globe continues

to spin the gas thinly coats the Northern Hemisphere before it swirls into delicate wisps and seems to disappear into the surrounding blackness. The image is both peaceful and disturbing in its evocation of a fluid smothering.

A playful quality pervades *Living Light Nos. 2-4* (2011; a photographic series) and *Bioluminescence Vol. 1* (2011; a video),

## ON OUR BOOKSHELF



### Superfuel: Thorium, the Green Energy Source for the Future

by Richard Martin

PALGRAVE MACMILLAN: 2012. 272 PP. £18.99

A key difficulty in mitigating climate change stems from the technological challenges in replacing fossil fuels, which — despite their drawbacks — are an extraordinarily rich energy source. In this book, writer Richard Martin introduces thorium as a nuclear fuel, inviting us to look at how nuclear energy might have developed differently during the Cold War era and its potential contribution to an energy revolution.



the work of artist Erika Blumenfeld in collaboration with Michael Latz (Scripps Institution of Oceanography, USA). Both exhibits address the microscopic world of phytoplankton, organisms that play a crucial role in the cyclic renewal of oxygen, and both play on the translation of touch into light. Erratic curves of vibrant white and iridescent blue streak across black space. These ghostly trails are produced by bioluminescent organisms when a force is exerted on their watery environment, either through the touch of the artist's hand or through an agitation chamber. Here, touch as a form of pollution is arguably submerged by the evocation of touch as a pleasurable feeling. Annie Catrell's *Fetch* (2012), by contrast, imparts a sense of the elements themselves at play. A cross-section 'drawing' spread over a series of glass tiles, *Fetch* depicts an undulating sea — etched in white and laid over a black background — that breaks as a wave on meeting a land mass.

More cautionary images do make themselves felt, however, in the work of Lucy and Jorge Orta (with Yadvinder Malhi, Environmental Change Institute, Oxford,

UK). Their *Amazonia Collection* (2010) is a gathering of painted, porcelain sculptures of terrestrial eggs and bones. An accompanying wall of photographs, *Perpetual Amazonia* (2010), depicts in vivid colour and detail the flowers that represent one-metre plots of the Amazonia forest. The whole conveys the plenitude of life in this region, which is so essential as a carbon sink, but also its fragility.

In a similar vein, David Buckland and Debora Iglesias-Rodriguez (National Oceanography Centre, UK) focus on the coccolithophore, an ocean dwelling, single-cell organism that secretes chalky plates, and is of scientific interest as an indicator of sea temperatures and carbon dioxide concentrations. *Cache* (2012) takes the form of an expansive blackboard wall with chalked scientific information and images, alongside a white, chalk floor that rises as a cliff. This work certainly highlights the scale and temporal presence of these organisms, whose chalk deposits, over time, amalgamate to become land mass. The accompanying *Chalk Shards* (2012) brings us back to more intimate scales, however,

as the vulnerable image of a human fetus emerges from the chalk deposits laid out in a cabinet.

What *Carbon 12* makes clear is that although the arts and humanities have much to say in regard to climate change, this is by no means a direct translation of climate change science, nor is it the articulation of a warning in regard to human activity. Rather, this is a creative response that makes vivid a complex, often paradoxical, sensual and emotional engagement with the environment. And, this is precisely the terrain on which hearts and minds are won. □

#### REVIEWED BY ELIZABETH STRAUGHAN AND DEBORAH DIXON

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■ *Carbon 12: Art and Climate Change*, 4 May–16 September 2012, Espace Fondation EDF, 6 rue Récamier, 75007 Paris, France. Curated by David Buckland.

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